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ELECTRICAL SECTION.

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Notes on Recent Electrical and Scientific Developments Abroad.

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THE VALTELLINA 20,000-VOLT THREE-PHASE RAILWAY IN ITALY.

About two years ago I had the pleasure of visiting the works of Messrs. Ganz & Co., in Budapest, Hungary; and through the courtesy of Director Otto F. Blathy, I was given facilities to study the company's 20,000-volt three-phase system for operating electric railroads.

I shall have the pleasure of presenting for your consideration to-night some lantern slides showing certain of the details of the original experimental plant built at Alte-Ofen Island in the Danube, near Budapest. I shall also supplement the illustrations in the paper by certain slides illustrating the details of the generating plant and railroad

equipment in Northern Italy, which I had the pleasure of visiting last September.

For nearly two years Messrs. Ganz & Co. have been installing this plant, and it was officially started up September 4, 1902; and this firm and the Societa'della Rele Adriatica, for whom the work was carried out, are to be congratulated upon the pluck and perseverance they have shown in

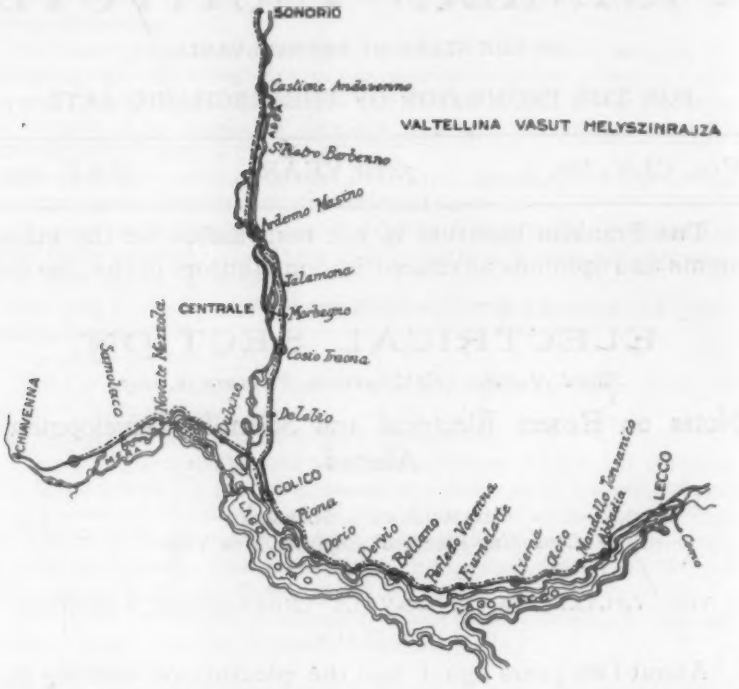

FIG. 1.—Map of system of Valtellina 3-phase 20,000-volt R. R. (power plant at Morbegno).

grappling with the well-nigh insuperable difficulties they have had to contend with, and the very able manner in which they have carried out this stupendous undertaking, which represents the most important and interesting electric railway installation in the world; and it is indeed remarkable that so little attention has been given by engineers, especially in this country, to this important and suc-

cessful effort to establish long-distance electric railroading under steam railroad conditions.

I arrived on the ground early in September, 1902, almost simultaneously with the starting up of the road, and spent some days traveling over the entire line; and, although the Lecco-Colico section was not being electrically operated at the time of my visit, all the rest of the road was; and I can bear testimony to the remarkable success of the operation of the road, which compared very favorably in smoothness and reliability of running, in starting and stopping, etc., with any road I am familiar with, either here or abroad; and I am informed that the company already has under contemplation the equipment of the road from Lecco to Milan in addition to the 72 miles already in operation.

This railway system has until recently been operated by steam, and is known as the Lecco-Sondrio and Chiavanna Line. In *Fig. 1* is shown a map of the line. Enormous difficulties have been met with in the installation of this plant, not so much in the employment of the initial voltage of 20,000 volts, but in dealing with the difficulties of the road-bed, which, as in all Italian roads, is execrable; also by reason of the length of the line, the problems in freight and passenger haulage, the very large number of tunnels the road had to pass through, the high winds and freshets in the mountain streams, and the difficulties in electrically equipping a standard gage road of 72 miles in length during the time that it was being constantly operated as a steam road.

The power-house, of which exterior and interior views are shown in *Figs. 2* and *3*, represents about 7,400 horse-power, with facilities for increasing this when necessary.

The plant itself consists of three 2,000 horse-power Shuckert three-phase alternators of the revolving field type, supplying 20,000 volts at fifteen cycles; these are direct-connected to three turbines supplied from a raceway between 2 and 3 miles in length, sections of which are open cuts through the rock, and other sections being through tunnels. The water is carried to the head stock 90 feet above the station and delivered at the rate of 35 cubic meters per second.

FIG. 2.—Valtellina R. R. water-power plant, at Morbegno.

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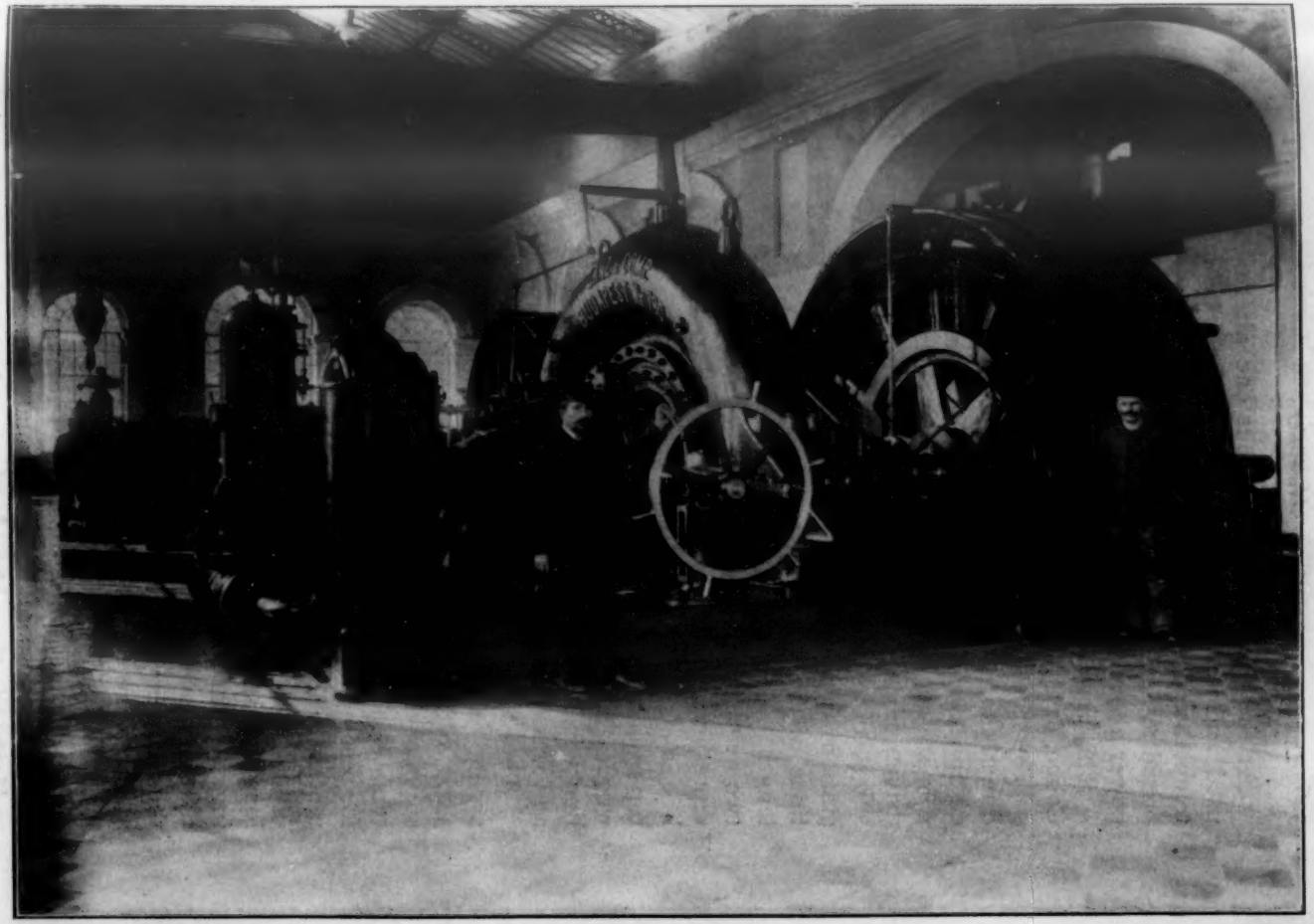

FIG. 3.—Interior of Morbegno central station.

At the time of my visit but one alternator was being used, and it was claimed that this could be made sufficient to operate the entire road; and the engineers have been surprised to find they would have such a very large reserve of power above all present requirements.

The power-plant is placed at Morbegno, 9½ miles from Colico, or 15½ miles from Sondrio.

The three-phase current of 20,000 volts is connected directly to the primary line, which supplies nine sub-stations equipped with ten 300-kw. Ganz transformers shown in *Fig. 4*, and the necessary switches, arresters and motor-driven ventilating devices for the transformers. At these sub-stations the current is stepped down to 3,000 volts; these stations furnishing current to the eleven independent sections of the overhead trolley line—each about 6 miles in length. Each of these circuits is equipped with fuses. The two overhead trolley wires, each 8 millimeters in diameter, represent two of the phases and the track the third. The line insulators have five petticoats, decreasing in size from top to bottom, and are made of porcelain. The poles are of wood, but eventually will be replaced by steel poles. The line wire, which is of copper, is 7 millimeters in diameter, and was doubly insulated and flexibly suspended.

The high-tension 20,000 feeders were carried over or around all tunnels, some thirty-two in number; but the 3,000-volt trolley wire passed through all tunnels, being supported from the roof at a height of 4 meters 80 centimeters. Especial privileges were accorded by the Government for placing these circuits below the regulation height of 6 meters, where they passed through the tunnels, and it was found necessary to replace the lateral suspension by a longitudinal suspension, owing to strains originally breaking the supporting devices. The increase of speed over that employed in operating the road by steam necessitated the changing of the pitch of the road, and also necessitated altering the trolley circuit to prevent the trolleys striking the tunnel sides. There are seventeen regular stations and eight extra stopping-places. The stations are supplied with incandescent lighting from the railroad power-plant at Morbegno through suitable transformers.

Passenger and freight traffic is operated independently. The types of these cars are shown in the accompanying illustrations, *Figs. 5* and *6*. At the time of my inspection they had ten passenger trains and two freight, and were

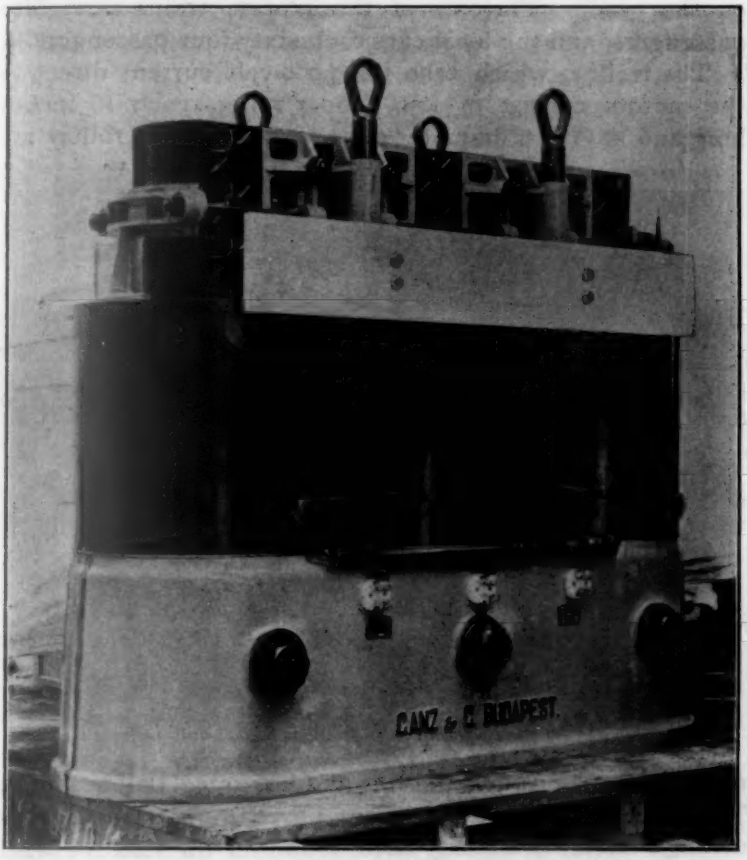

FIG. 4.—300-kw. Ganz transformer, Valtellina R. R.

expecting, in addition, three more passenger and two more freight trains.

The freight locomotives (one of which is shown in *Fig. 6*) are approximately 700 horse-power, employing four motors, and are capable of hauling 500 tons on the level at a speed of 19 miles per hour.

The passenger locomotives are also equipped with four primary motors, operated in parallel, each weighing about 3½ tons, and representing 300 horse-power. A truck equipped with two motors is shown in *Fig.* 7. The schedule speed is about 37½ miles per hour on the level, and about half that on the grade. The cars of the express trains carry fifty passengers, and the local cars each sixty-four passengers.

The trolleys which take the 3,000-volt current direct to the motors consist of two copper rollers, each 16 inches long and having a diameter of 3¼ inches. These rollers are

FIG. 5.—Express passenger train, Valtellina 20,000-volt 3-phase R. R.

mounted in the same axial line and have steel ball-bearings. These bearings, however, do not have any current passing through them, it having been found in all trolleys with ball-bearings that the passage of the current through them soon pitted and roughened the surfaces. To the left and right of these pairs of rollers are copper cones about 8 inches long, rigidly attached to the trolley support. The base of the trolley is supported on the top of the car, and has a long horizontal hinge, and the trolley is connected to the piston of an air-cylinder supplied by the air-brake

apparatus on the train, so that the trolley can be readily raised and lowered—a dash-pot preventing jar. The trolleys are plainly shown in *Fig. 6.*

Each of the primary or high-tension motors has its trolley with double rollers. The current is taken from the two rollers by collecting-brushes running in contact with graphite collars, against which they are held by spiral springs. The current is taken from these trolleys by highly insulated wires inside of grounded metallic tubing, 3,000

FIG. 6.—Primary or main line switch (3,000-volt).

volts being supplied direct to the motor. Each car is mounted on two four-wheel trucks, one of which is indicated in the appended illustration, *Fig. 7*, and is equipped with two "primary" and two "secondary" induction motors, there being in all four motors of 150 horse-power each.

The rotors each weigh about a ton and a-half. The air-gap is only between 4 and 5 millimeters.

In starting up a train or climbing up a grade the motors are connected in "cascade," or, in other words, while the

3,000-volt current is direct-connected to the stationary windings of the "primary" motors the windings of their "rotors," which are designed for 300 volts, are connected to the stationary windings of the "secondary" motors, while their "rotors" are in turn connected to a fluid resistance. This arrangement gives a speed of about 18½ miles per hour. The controller is thrown to but two positions—*i. e.*, half-speed and full-speed.

When the handle of the controller (shown in *Fig. 8*) is thrown to the second or full-speed position the stationary

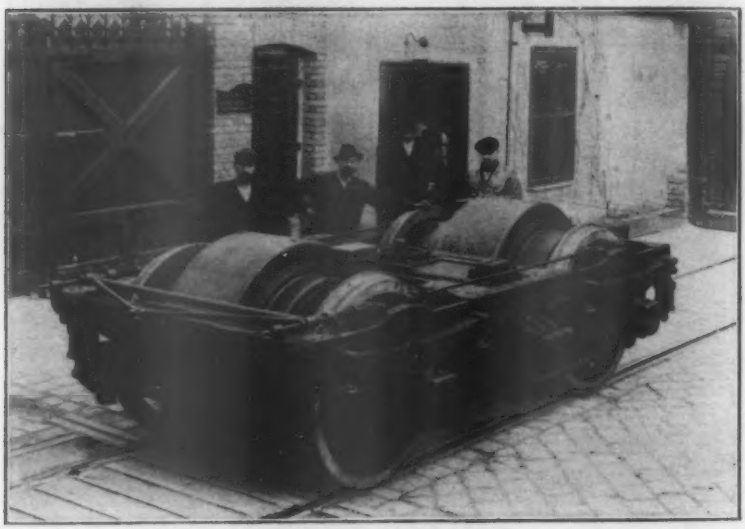

FIG. 7.—Motor car truck, Valtellina R. R., Italy.

fields of the two "primary" motors are then thrown directly on the line, and their rotors are connected to the fluid resistances, which are slowly cut out of the circuit. In the meantime the "secondary" motors have been cut out of the circuit. This full-speed arrangement gives approximately 37½ miles per hour.

The controllers at each end of the car are connected mechanically, and the high-tension switches are connected electrically. A special device renders it impossible for any one to open the boxes containing the high-tension switching

apparatus until a key has been removed from the trolley device; and this key cannot be removed until the trolley has been lowered and the circuit thus opened, rendering it perfectly safe.

A high-tension switch carrying the 3,000-volt primary current is shown in *Fig. 9*, and consists of a horizontal iron

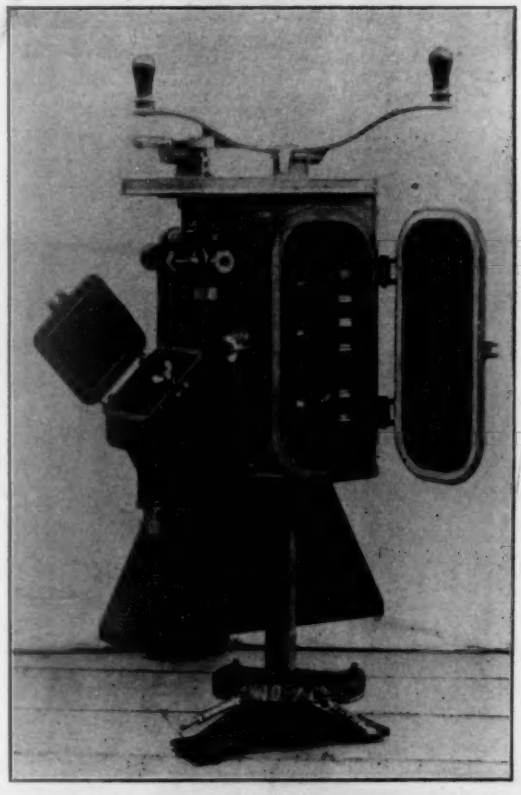

FIG. 8.—Controller, Valtellina 20,000-volt 3-phase R. R.

plate pivoted on a vertical shaft ending in a rack which engages a pinion worked by a crank. The plate is raised by turning the hand crank—this plate having six porcelain-backed bolts with steatite heads mounted on the upper side.

The collecting current circuit is connected to three copper sockets sunk in porcelain insulators, the cables to the three

motors being similarly connected to three sockets. All of the six sockets are directly above the plates which are raised by the crank.

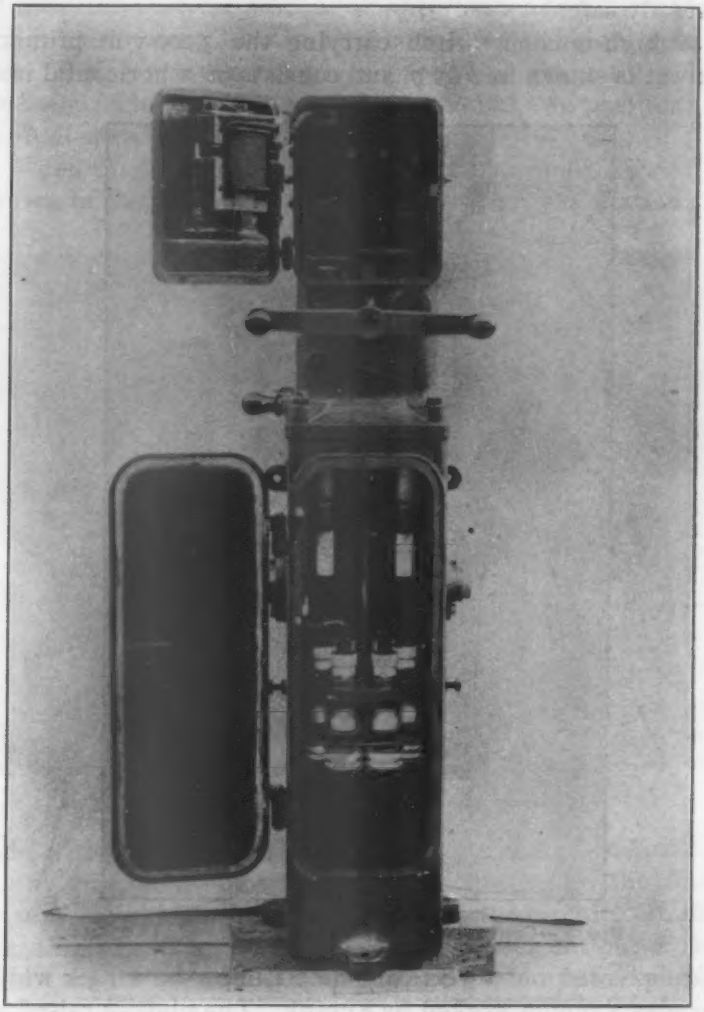

FIG. 9.—Primary or main line switch (3,000-volt.)

The insertion of the bolts into the sockets establishes a perfect connection, and on their withdrawal a rarefication of the air is produced, which to some extent prevents the

formation of an arc, which is further assisted by the steatite heads.

Reversal of the current to the motors may be effected by rotating the lower switch-plate on its vertical axis. A relay placed in the return circuit to the rails causes a cutting off of the current to the motors by lowering the switch-plate should a safe limit be exceeded.

A special device is also provided in case of the potential

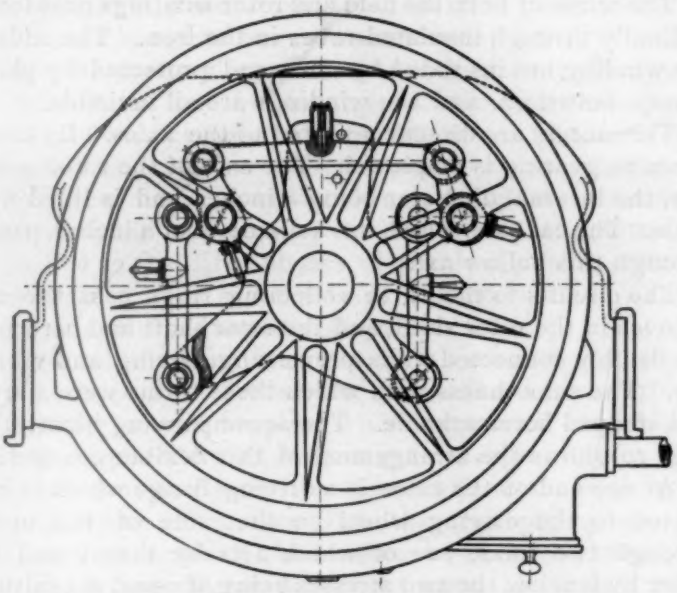

FIG. 10.—Showing flexible coupling for connecting motors to wheels, Valtellina R. R., Italy.

falling, due to a break in the line, by means of which device the 3,000-volt trolley circuit is grounded.

The arrangement employed on this line is such that it is impossible for two trains to move upon the same section of track in the same direction at the same time, as each train leaves the section behind it dead, re-establishing the circuit as soon as it has passed into the next block.

The signaling system employed, when set against an approaching train, at the same time cuts off the current

from that particular section until the train is given the right of way.

The brakes on the train are also automatically applied the moment the train endeavors to enter a section over which the preceding train has the right of way.

During the entire time of operating this road but one accident has occurred, and that was due to a workman forcing the door of the high-tension box open, and thus somewhat severely burning his arm.

The wires of both the field and rotor windings pass longitudinally through insulated tubes in the iron. The ends of the winding are insulated by mica and protected by plates or caps bolted on, and the windings are all invisible.

The motors are direct-connected to the axles. By this I mean no gearing is employed. The axle of the rotor is hollow, the internal diameter being 8 inches and is lined with brass. The car axle, which has a diameter of 4 inches, passes through this hollow axle.

The circuits to the three collecting rings pass through grooves in the rotor shaft, and the rotor shaft and car wheel are flexibly connected, thus preventing jarring and vibrating. The smoothness with which these trains were started and stopped is remarkable. The accompanying illustration (*Fig. 10*) shows the arrangement of this flexible connection.

At one end of the rotor is a driving flange which is connected to the driving wheel on that side of the motor through two links, one of which acts by thrust and the other by tension, the two stresses being of equal magnitude; at the other end of the rotor the three collector-rings, upon which rest the three carbon block brushes supplying current to the rotor.

A 100-volt three-phase motor is supplied with current through an 8-kw. transformer connected to the line and is used for compressing the air for the air-brakes, for raising and lowering the fluid in the resistance boxes, and for raising and lowering the trolleys and automatically operating the high-tension switches.

A circuit from the same transformer supplies current for lighting the train. It was found that the low periodicity of

15 per second caused such noticeable fluctuation in the light of the ordinary incandescent lamp, that three-phase or three-filament lamps were made by both the Cruto and Ganz Companies for this purpose, and are being very successfully employed. I saw lamps of both of these types tested on the circuit, and the three-phase lamps were remarkably steady, while the others were not. I have samples of these three-phase lamps here for your consideration, which I shall describe later.

The liquid rheostat employed on these cars is very ingenious, and has given very satisfactory service. It is a three-phase rheostat, and consists of an iron box with three wings to it, from the top of which depend three separate cylinders. Inside of each cylinder are two sets of iron plates which are rounded at the lower extremity, and vary in length. The alternate plates are connected in pairs, the current entering by one plate and leaving by the other; the sets being attached to the three phases of the low-tension roller circuits, which have a potential of only 300 volts. A cooling device is attached to these rheostats.

The solution employed is sodium carbonate contained in the lower portion of the outer case. The upper portion of this outer case is supplied with compressed air, which, on being supplied to the case, in a greater or less degree, allows the solution to rise in the three cylinders. In rising, the liquid comes in contact with the iron plates, one after another, thus cutting the resistance out of the circuit to a greater or less degree, dependent upon the height of the solution.

This plan, it will be readily seen, is much simpler and far preferable to the raising of the plates out of the liquid.

The device is the result of extensive experimentation, and permits the motor-driving torque to be kept constant during acceleration. The entire height through which the solution passes is less than a foot.

The exhaust valve is the lift type of valve, normally kept open by a spiral spring, and the valve for operating the rheostat is compound-wound, having several openings through it. On being operated the compound valve

first opens a clear way for the compressed air to the cylinder and to the top of the piston, which compresses the spiral spring of the exhaust valve already referred to, and closes this exhaust valve. The air then slowly passes through a small throttled aperture, admitting the air to the outside of the resistance box casing at a low pressure.

When half speed has been attained, the motion of the trolley lever when thrown to full speed causes the air-cock to close the throttling aperture, opening another aperture, and thus relieving the air above the upper surface of the exhaust valve piston, permitting the compression spring of this valve to instantly open, it thus throwing in instantly the whole resistance.

The operations described are repeated in securing acceleration from half to full speed, and in securing retardation from full to half speed, at which time the motors operate in "cascade," as already described.

The Arcioni three-phase recording wattmeter, manufactured by Camillo Olivetti, of Ivrea, Italy, is employed to register the entire output of the Morbegno plant. This wattmeter, I found, is being used extensively in various high-tension plants throughout Europe and is giving very great satisfaction. I know of no instrument for this class of work which has given as satisfactory results. No oil switches are employed in this plant, ropes being used to pull the levers attached to the high-tension switches overhead; and to these are attached Siemen's horned lightning-arresters.

I was informed that no lightning has ever entered the station, and the protection is doubtless due to the very interesting lightning-arrester. Three jets of water are thrown into the air, each jet coming within a short distance of a tap taken from one of the three-phase lines of the high-tension circuit. Any lightning disturbance passing over the line will jump across the intervening air-space, and pass through the water to the ground. The device is most simple, and thus far has proved very effective.

In preparing the data on this most interesting engineering development, I am very much indebted to Director Otto F.

Blathy and Mr. Kando, chief engineer, to whom the success of this system is largely due, and to Mr. Lello Pontecorvo, one of the engineers of the Ganz Company, in charge of the work, who very courteously took me over the road, through the power-house, etc., and furnished me with many of the engineering details. The illustrations and lantern slides which I have presented are from photographs made by myself, and from photographs and drawings furnished me by the Ganz Company.

THREE-PHASE CRUTO AND GANZ LAMPS. OSMIUM AND NERNST LAMPS.

I wish now to present for your consideration several of the most recent European developments in incandescent lighting. These comprise the three-phase lamps of Messrs. Ganz & Co., of Budapest, Hungary, and the Cruto Company, of Italy, such as are used on the Valtellina Railroad, two samples of the Osmium lamp and samples of the latest types of Nernst lamps from Germany and France.

Each of the three-phase lamps are of 16 candle-power, intended to operate on a three-phase circuit of 15 cycles at 110 volts. The filaments employed in these lamps are of carbon, but some lamps have been recently designed on the three-phase principle employing Nernst glowers. One of the lamps closely resembles the ordinary Edison lamp with a screw butt, and protruding from the center of the usual button at the bottom, and insulated from it, is a split pin forming the third connection. The other lamp has a brass collar with three pins protruding at equally distant points, intended to lock in a bayonet catch in the socket. At the bottom of the base, which is of insulating material, are three round contact points, which, by their relative positions, form a triangle. These points are adapted to make a rubbing contact on three corresponding contacts in the socket.

The Osmium lamps are the shape of an elongated egg. They have butts similar to the Edison lamp and porcelain insulation. The filament is anchored to the side of the globe by a glass projection terminating in a spiral of a sin-

gle turn made of material similar to that employed in the Welsbach mantle (which, as is known, is composed of thoria and ceria), this substance taking the place of the platinum wire usually employed in anchored filament lamps. These Osmium lamps are coming into use to a very limited extent abroad, especially in Germany. It is the invention of Dr. Auer von Welsbach, and the invention is controlled both abroad and in this country by the Welsbach interests. It is claimed that so long as the filament remains intact it may be renewed several times. The filament is light gray in color, and in the single filament form, unless anchored to the side of the globe, it is impossible to burn it except in an upright or pendent position (preferably the latter), as the filament, which is very long, is so flexible that it curls over against the glass. The lamps show a very high efficiency, and they have done very well in the life tests.

In a test referred to by Scholz, an Osmium lamp, after burning 1,500 hours, was still intact, and had fallen off in candle-power but 12 per cent., its efficiency in starting being 1·45 watts per candle-power, and at the end of 1,500 hours it showed an efficiency of 1·7 watts per candle-power. The present range of voltage of the Osmium lamp is from 25 to 50 volts. A number of filaments can, however, be connected in series or in multiple series for higher potentials; a few lamps have been made with two filaments in series.

It is to be remembered that Mr. Edison and other inventors many years ago endeavored to manufacture filaments for the incandescent lamp by incorporating carbon and metallic oxides or rare earths and finely divided particles of metal; but experiments in this line have thus far met with but little success.

Osmium, from the Greek osme (smell), so named from the strong, disagreeable odor given out by its oxide, is a blue-white metallic element, and well-nigh infusible. It was discovered in 1803 by Tennant, and was for a considerable time known only as crystalline, grain-like material; and when fused in the electric arc, as a hard brittle substance unfit to be worked. It is secured in the refining of native platinum and from iridosmine. It has an atomic weight of 190·8.

Among the difficulties to be met with in manufacturing and exploiting the Osmium lamp on a considerable scale are the great rarity of the material used in its manufacture and the very low voltage of the lamp, which necessitates the placing of several filaments in series where the direct current is used. Certain tests which have been published abroad show a saving of 60 per cent. as claimed by the Osmium lamp over the carbon lamp, this test being made on four 25-volt Osmium lamps in series in competition with four 100-volt carbon filament lamps in parallel; the Osmium lamp showing a consumption of ·96 amperes and the carbon filaments 2·40 amperes. Recently some results have been published by Remane of tests upon an installation of 300 Osmium lamps made in Berlin, covering a period of ten months. These tests show a very slight diminution in candle-power when operated upon an alternating circuit of 30 volts, and show the consumption of energy to be 1·5 watts per candle, which is 50 per cent. higher than the 3-watt carbon lamps extensively employed. The cost of these lamps is $4\frac{3}{4}$ marks each, or a little over $1.

The Nernst lamps shown are of two types, the small French lamp being of the alternating type, and it is practically identical with the standard type of lamp manufactured in Germany, with which you are doubtless already familiar, and which I have quite fully described in a paper which I gave before the American Institute of Electrical Engineers, February 28, 1901, entitled "Important European Electrical and Engineering Developments at the Close of the Nineteenth Century."

The large lamp is of the direct-current type intended to operate from 65 to 135 candle-power to fill an intermediary position between the incandescent and arc lamps. The heating coil is a conical spiral which is in a perpendicular position when the lamp is pendent, and the "glower" is in the center of this heating coil. The iron ballast wire is mounted as in the tiny incandescent lamp globe, which is filled with hydrogen gas to prevent oxidation, and screws into the base of the socket. The replacement piece is so arranged that it is impossible to reverse the connections in

attaching it to its support, and the plugs on the socket itself are marked plus or minus, and are not interchangeable. As is well known, it is absolutely imperative to send the current through these direct-current types of lamps always in the same direction; and even then the life of the direct-current lamps is exceedingly low, seldom exceeding 300 hours, and with probably a maximum of 400 hours, whereas the alternating-current lamp can be readily made to give a very satisfactory life.

I have been surprised in visiting the ten countries in Europe which I set foot in during the past summer to find such a dearth of Nernst lamps. Even in Berlin, the home of the parent Nernst Company, I found places where the Nernst lamp was in use two years ago where there was not a single Nernst lamp, and there were few of them to be found anywhere; and in the important expositions which I visited at Dusseldorf, in Germany, and Wolverhampton, in England, there was not a single Nernst lamp in operation.

From what I have seen of the foreign types and the American types of Nernst lamps I am led to believe that the most commercial type of Nernst lamp that is being made to-day is that of the American Nernst Company, which has up to the present wisely confined its energies to producing one single commercial type of lamp, whereas the foreigners have been endeavoring to manufacture and exploit lamps for both direct and alternating currents and a great variety of types, each of which has introduced enormous manufacturing difficulties.

[*To be concluded.*]

DETERIORATION OF LEATHER.

A very striking instance of the deterioration of leather produced under conditions demanding quicker tanning by the use of various chemicals, thus decreasing the durability of the material, is afforded by the fact that the British Museum expends $20,000 a year in rebinding books in leather. Modern leather is entirely different from the material produced by what is now regarded as an effete process, its life being limited to fifteen years. In the search for cheaper and quicker processes of making leather, large quantities of sulphuric acid are used, and this substance, in combination with others, causes the material to decompose rapidly in the course of a few years.—*Scientific American.*

The Forest Policy of Pennsylvania.*

By George H. Wirt,
State Forester.

Mr. Chairman, Ladies and Gentlemen:—Dr. William Schlich, the noted English forester, says that the task with which forestry has to deal is to ascertain the principles according to which forests shall be managed and to apply these principles to the treatment of forests. Dr. C. A. Schenck, of Biltmore, North Carolina, gives a very terse definition of forestry and one that is broader than most others. It is: "Forestry is the proper handling of forest investments." He takes into consideration the facts, first, that forest land and forests themselves shall be dealt with as any other investment, namely, that there shall be a yearly return of some kind; and second, that a forest investment may be for some other purpose, primarily, than for yielding a return in wood alone, which indeed may not be considered at all.

From a private standpoint, no matter what the immediate purpose in the management of forests, the ultimate one is usually of a pecuniary nature; yet, under existing conditions, there are many reasons why forestry is not a profitable investment for an individual. Unlike stock, which can be put upon exchange at any time and sold for its market value, a forest cannot be sold at the owner's will. A favorable time must be awaited or, in case of a forced sale, a great loss is usually sustained. Even under very favorable circumstances a forest investment will yield a small rate of interest in comparison with many other projects where money is needed. The present system of taxation, too, takes from the forest-owner not only the profits of his forest each year, but in many cases, if the tax is computed at compound interest

* A lecture delivered before the Franklin Institute and the Central Branch of the Y. M. C. A. in Association Hall, Friday, January 23, 1903.

for a less number of years than it takes a forest to mature, the amount is far more than the original investment, together with what could be obtained from the mature wood and the land. Add to these adverse conditions the uncertainty in regard to partial or total destruction by forest fires, and we can excuse any one for not practising conservative lumbering.

On the other hand, because of certain economic influences of the forests, the State, which is long-lived, can afford to practise forestry and receive a small rate of interest, or even none at all, for some time. One of the first duties of any State is to provide for its own welfare and for the continuity of its life. It has been proved beyond a doubt that forests do influence local climates and water-flow, making possible successful agriculture and fruit-growing, and to any State the agricultural interests are well worth caring for. In few of our Eastern States is the capital and labor employed in the harvesting and the final manufacture of wood less important than that of agriculture. The preservation of such an industry will surely be of advantage to a State.

Moreover, if the State practises forestry on its own land, private individuals will be very apt to pay more attention to their wood-lots and forests; and at the same time, if the State regulates a sufficient area of forests to supply the indirect influences desired, private holdings can, to a great extent, be disregarded. In America, disregard very often is better relished than that which is thought to be an encroachment upon a freeman's rights.

The attitude which any State takes with regard to its forests, however, will be influenced by one or all of four conditions, namely, by the requirements of the country as determined by the number and the culture of its people; by the nature of the proprietorship of the forests; by the existing area of forests, or by the amount of waste land within the State.

In a thinly settled country there is no need of caring for the forests, because the people have few wants and they are easily supplied without disturbing to any great extent the character or area of the forests. As the population and the

desires increase, however, not only the forest is disregarded, but even the rights of neighbors or the good of the community may be lost sight of. Finally, it is the culture, toward which the forests have so largely contributed, that in turn demands the protection and the management of forests at the hands of the State. If it is true that the culture of a people is shown by the condition of the roads, it is equally true that it is shown by the protection afforded to the forests and the management demanded for them by the State.

In the case of a country where the forests are owned by private individuals, or by companies, the attitude of the State toward the forests will depend very largely upon the character of these owners. They may be men who have vast interests at stake and have already recognized the fact that their forests, with some extra care, can be made to yield them a revenue indefinitely. The interests of the community are injured in no way by a suitable forest area, but rather bettered, consequently the State should give ample protection from fires and should regulate taxes so that this condition may be continued. But it is more likely to be the case that these private holders are men who desire a large revenue immediately from their forests, and clear them from high mountains and steep hillsides without regard to a future growth. The results are a rapid run-off of rainfall and melting snow, causing floods and the erosion of the soil.

In many cases these two results may entirely prevent the continuance of profitable agriculture in the neighboring valley. The value of the land rapidly decreases and at the same time the possibility of its becoming valuable again is lessened. Such a condition of affairs is detrimental to the State. One of two things must be done. If protection is already afforded by existing conditions, laws must be passed restricting the rights of individuals on their own land so far as these rights interfere with the rights of others and the welfare of the community, or the State itself must take hold of the forests, or a part of them, and care for them. Where forests are owned and properly cared for both by

individuals and by the State, the latter must come in conflict with its citizens as little as possible.

In a country like Maine, a considerable part of which is wooded, the wealth of the State depends to a very great extent upon the forests. From the time it was first settled the lumber industry has been a predominant one; but gradually it has declined from what it once was, though still of vast importance because of the spruce which is so important in the manufacture of wood-pulp. At the present time, because of the tremendous water-power available, the manufacturing interests have become greater, but their stability depends indirectly upon the forest, nature's water-reservoir. Maine certainly has enough land under forest cover, or what may be called forest land, and her policy must be such as will be necessary for the maintenance of existing forests.

In the prairie States, agriculture and stock-raising are the important industries, but many times neither is possible without great loss because of the wind-storms which frequently pass over the country. There the policy of the State would be that of increasing the forest area. Premiums might be given for plantations, plants raised and distributed—anything in fact that would be an inducement for the people to plant trees, until the advantages could be appreciated, and then the work would go on without State aid. In Nebraska this work has been successfully commenced, owing to the impetus given by the late Hon. J. Sterling Morton.

Again, if the country is in such a condition that each acre of land is yielding its maximum return, that condition is an ideal one and the Government need not concern itself with inducements for changes in management or for a more intense culture. This ideal condition is seldom found; the reverse is common enough. Thousands of acres in this country are not only producing no revenue, but actually causing a loss to their owners and to the Government. In the economy of nature, trees have been made to grow where no cereal or textile crops can be produced, and to improve the soil by their being on it. Forestry does not ask for soil that can be used for more profitable purposes, but it does

ask for, and should by all means have, the land that is fit for nothing but tree-growth. Very often waste land is the result of some policy of the Government. It may be lavishness or it may be exaction. Land may be too easily had to care for old land when the fertility begins to fail or the burdens of taxation and risks from fire may be too heavy. Either case produces the same result. It is to the advantage of the Government that each acre of land should yield its maximum return, and its policy must be such as to bring about such a return as early as possible.

The policy of our own State, "Penn's woods," in relation to its forests, both in the past and what it should be in the future, must be of interest to every citizen.

William Penn recognized to some extent the value of the forests in his Province; for in an instrument dated July 11, 1681, and intended as a Charter of Rights to the colonists, Section xviii reads thus: "That in clearing the ground, care be taken to leave one acre of trees for every five acres cleared; especially to preserve oak and mulberries for silk and shipping." This implied not merely that $\frac{1}{5}$ part of the Province should be left in woodland, but that this woodland should be cared for as a source of profit both to the citizens and to the Government.

After two centuries of disregard for the far-seeing policy of Penn, a few of our public-spirited men were brought face to face with the fact that a great change was taking place within the State by reason of the rapid and unnecessary destruction of the forests. These men devoted themselves to the task of remedying, if possible, the adverse conditions already existing, and of protecting the State in the future from worse conditions that were sure to follow the reckless and wasteful methods of lumbering then going on. Exact data were collected, as well as numerous photographs from all over the State. Then began in earnest the forestry propaganda. First of all the people had to be educated and brought to realize the meaning and the need of forestry. Difficulties were not wanting, but with each new discouragement the men most interested in the State's welfare set forward with a more determined heart. A review of what

has been accomplished in less than a quarter-century will show how well the work has been done.

Previous to 1880 there were several laws upon the statute books, the import of which was "to prevent the burning of the woods" and to bring to justice persons guilty of such offense. The penalty varied from $50 to $500. That they were ever enforced we have no knowledge, but they served at least one purpose—a precedent.

In 1886, the Pennsylvania Forestry Association was founded and has been a growing power. The next year an act "for the encouragement of forest culture," by a rebate of taxes on land planted up with forest trees, was approved. This law recognized one step in advance of anything that had gone before, namely, the benefit of forests to a community and that the community should pay for its benefits.

In 1893, a Forestry Commission, consisting of a botanist and a civil engineer, was created. The commission made its report to the Legislature in 1895, which was printed as Part II of the Report of the Department of Agriculture. It was widely circulated and has done more, perhaps, toward forming a popular interest in forestry in this State than any other publication. In that same year, when the Department of Agriculture was created, a Division of Forestry was provided for and a Commissioner of Forestry appointed.

Two years later, in 1897, Governor Hastings approved an act "authorizing the purchase by the Commonwealth of unseated lands sold for the non-payment of taxes, for the purpose of creating a State Forest Reservation." This was the foundation of the present reservation system of the State. In 1899 this act was amended by authorizing the Commissioner of Forestry, under certain provisions, to purchase unseated lands other than those offered at tax sales.

In 1897, other laws, making constables of townships ex-officio fire-wardens, providing for the expense of suppressing fires, to be borne equally by the State and county, and for the punishment of offenders, were approved. A special act was also passed to secure State Forest Reservations at the head-waters of our three principal rivers. These laws

placed forestry on a sure footing and gave it an impetus that cannot be halted.

The importance of the work so impressed Governor Stone and the Legislature that in February, 1901, the Division of Forestry was raised to a department, with the Commissioner of Forestry as chief of the department, and at the same time President of the Forestry Reservation Commission. The powers of the Commissioner were increased, and to-day, because of the whole-hearted and efficient work of the present Commissioner, who has held the appointment since the creation of the office, our State stands in the lead of those taking up forestry work, and it is possible to say that, as whole, the people of our Commonwealth have nothing but good words for the forestry movement. The success which has come is due, no doubt, not from asking the public to accept an ideal at once, but from starting on the right road and gradually, step by step, leading up to the position desired.

Now, the policy of the future. First of all, it shall be, as it has been, practical. Forestry is a business, and the preservation and perpetuation of our forests must be done on a practical business basis, not on any æsthetic or sentimental basis. Of the utmost importance is the continued education of the people. Notwithstanding the work done in the past, traveling through the country one frequently meets people with very queer ideas in regard to the forests and to the meaning of forestry. Such people are the ones who must be reached. But they are not the only ones. The people of the cities and the larger towns, too, are not as well acquainted with the principles of forestry as they should be. There are two ways by which this condition can be changed.

The Governor issues a proclamation each year naming two spring days for the planting of trees and shrubbery by the citizens of the State, and the Superintendent of Public Instruction, in accordance with the Governor's proclamation, urges the observation of the day in the public schools. Whether the day is observed by a school lies usually with the teacher, and it is a question whether one-tenth of the schools do observe it. The importance of spreading the

interest in Arbor Day is that through it the children can be reached. If a child can be induced to help plant a tree, and watch it grow, or, better still, to plant a seed and await its development, that child will learn to love the tree and to look upon it as a friend. A very few words in connection with such an exercise would teach the child the use of the forest and the value of trees. Arbor Day, then, might be made a necessary part of the school-work, or if that is too radical, at least the Department of Public Instruction, or the Department of Forestry, or the two working together, might publish an annual bulletin containing appropriate matter for various programmes, getting it up in an attractive form, to be distributed to the teachers all over the State. Other States do this, and very good results have been accomplished. If the children of to-day appreciate the forests, the forests in the future are safe. The Superintendent of Public Instruction also names an autumn Arbor Day, to be especially observed by the public schools of the State.

Arbor Day, when made popular, will necessarily reach a number of the older people, but they must be presented with graver problems and shown how these are to be solved. There is no better opportunity at present for this than making use of the farmers' institutes. This is an open field and should be filled at once. Some phase of forestry should be made a part of each programme. Arrangements can be made for this field through the Department of Agriculture.

One of the greatest questions which the State has to meet in this connection is the utilization of the large amount of land, at present valueless, which is classed as agricultural land, and which is, as a matter of fact, an expense to the owner instead of a profit. The time is here when our farmers must practise more intense farming, concentrate their energy upon the best of their land and allow the remainder to regain its fertility by reforestation. Pennsylvania may be claimed as one of the greatest agricultural States in the Union, and yet a good authority estimates the waste land attached to its farms at about 4,000,000 acres. This land

must not continue longer as a menace, but must be, as it were, redeemed to the people. It would be impossible for the State itself to care for such areas, consequently the policy must be toward helping the private owners to do the work. Already a reduction in taxes is offered for plantations, but this is not sufficient. Some system, such as Canada has, will bring about quicker and better results in connection with the rebate. Personal attention is offered each farmer as he applies for aid, a forester giving instruction as to the preparation of the soil, the species to plant and the method of planting. The farmers could raise their own seedlings, or better still, they could be raised in the nurseries on the reservations and distributed at a nominal cost. Free distribution would lead to wastefulness, and distribution without instruction in most cases will amount to failure.

Beside this large amount of waste agricultural land, there are about as many acres of so-called forests which are practically waste in their present condition. Much of this is in such a shape that it can be held only by private people. The value of a wood-lot on a farm is generally recognized; but many people, from gross ignorance of the requirements of tree-growth, have managed their wood-lots in such a way that little more than firewood can be obtained from them. From instruction at Institutes the farmer can adopt a better system of management and in a few years have an improved forest. However, the owner must be helped in other ways. A wood-lot is of advantage to more than its owner, consequently the taxes should be shared with the township or county. This is already provided for in a way; but just at a time when the trees are growing most the full tax is lifted and the owner must cut his timber to make his profit. The rate of taxation on forests ought to be very low, or some basis should be established whereby only the value produced each year is assessed.

In addition, the existing fire laws must be vigorously enforced to protect the property upon which taxes are paid. Offenders must be brought to justice and punished with a fine corresponding to the crime. Objections have been raised to the fire laws as they now stand, but they are the

best that could be obtained at the time. If an advance can now be made, the present Legislature will make it. One improvement would be the appointment of a chief Fire Warden, with a number of sub-wardens, all under the direction of the Commissioner of Forestry, whose duties shall be to keep a lookout for fires, see that the ex-officio fire wardens do their duty, and to act as detectives when fires occur. It is cheaper to prevent fires than to pay for putting them out and to bear the loss they cause. In a larger sense must this protection be given to owners of extended forest areas, and wherever desired or possible the State forest officials should aid private parties with the management of their forest land.

Pennsylvania has recognized both sides of the forestry question—private and governmental. Her policy has been to aid in making private forestry not only possible but profitable, and at the same time she has felt that the forests at the head-waters of the principal streams should be managed, not by any system that would change with the whim or necessity of an individual, but by a system of forest management which has the greatest good to the greatest number in view at all times.

In 1898, the Commissioner of Forestry purchased some land at tax sales, but this was allowed two years in which to be redeemed. In March, of 1900, the first land actually passed into the possession of the State. Since then the reservations have gradually increased until, at present, land is owned in twenty-two different counties. In less than two years the State has actually paid for over 400,000 acres of land and the Reservation Commission has almost as much more under consideration. Not an acre has been bought without a previous examination to determine the character of the timber and the location of the land. The owners first make an offer of the land to the Commission. It is then examined and an estimate of its value for reservation purposes placed upon it. If the commission accepts the land on this report, and the price is satisfactory to both parties, it passes into the hands of an experienced title examiner. If the title is clear, the land is deeded to the Commonwealth and paid for at once. When any defect in a title is found,

it must be satisfied before the Commission will accept a deed, consequently there will be no fear of future trouble arising from imperfect titles. So far, it has not been necessary for the Commission to ask for lands, nor has it been necessary to use the right of eminent domain. It is to be hoped that the latter never will be resorted to, but the purchase should continue until at least 2,000,000 acres can be claimed as forest-producing recreation grounds for our people. When that amount has been obtained, conditions may demand that more be managed by the State.

The management itself of these various reservations is the most interesting question facing the Reservation Commission. However, it seems that there ought to be very little difficulty in this direction. There are no laws which hamper in any way the necessary progress. The greatest need is trained men who can carry the work forward. Of course, any work implies a sufficient appropriation, and this should not be slight, for it must be understood that the money paid out for these lands and for their care is not an expense. It is an investment, and a good one, for the State. Some have said it is a "grab" upon the treasury, but it is no more a grab than is the legitimate and necessary appropriation to the public schools, for the forestry management will result, not only in a money return to the treasury, but in a continued industry of the State, purer water for our cities and better health for our citizens.

As long as the State continues its purchase of land the present reserves will be changing their boundaries more or less, but this cannot alter the fact that what has been purchased already must be cared for. Better not have it than not care for it. The first step toward the protection of the reserves must be the survey of the boundaries. It settles at once and forever the ownership of the land and sets the bounds within which the reservation officers are expected to know every detail. The mere boundaries, however, are not enough for a forester. He should have what is called a "forest survey." Upon it he bases his plans for a given period in the future. Primarily he must know the amount of wood at his disposal, its position, its kind, its quality, its

age, and so forth. To plan for the marketing of the produce at the least cost a topographical map should be available, showing contours, streams, roads and trails, and for other purposes the clearings, houses and all points of interest should be marked.

Like other arts, forestry has an ideal toward which all efforts trend. It is what is known as the "normal growing stock" and the "normal annual increment." The normal growing stock is the largest amount of desirable wood that can stand on a given area, being in such proportion as to age gradations that an equal amount of wood is matured each year, which equals the normal increment. While this ideal can never be reached, yet it is important that the condition of the forest be brought as near to it as possible, for not until then will the forest produce its largest revenue. In other words, we may consider part of the forest as capital and part as interest. There may be too much capital invested to yield the highest returns. In that case some of the capital in the shape of trees must be taken out. There may be too little capital invested, consequently it must be increased as rapidly as possible. The latter is the condition of most of our reserves, and the longer we delay in bringing the capital of the forest to its proper level, the more money is lost to the State in the future.

One of the best ways to increase the value of the forest is to make good, serviceable roads. The roads of this country are notorious for their lack of any good qualities, and yet enough money has been spent upon them to make their dust as valuable as gold. Fortunately, the good-roads movement is gradually gaining force and every patron of forestry must be a patron of it. There are many instances in Germany where profitable forestry could be practiced only after the building of a road through the district. The same thing is and will be true in our State.

Within the reservations the Department of Forestry should have entire control of all roads, at least so far as is necessary to build a complete system of serviceable roads and trails upon each reservation. Where changes in the present roads are desirable, the department should be at

perfect liberty to make such changes. Already a slight provision has been made along this line. Of course the State pays no taxes on its land. To compensate the township, $25 for each mile of public road within the reservation in that township is allowed to be expended by the Department of Forestry for repairs. Thus far the expenditure, where made, has been of very great value. In two years one road in Pike County has been transformed from a rough and muddy road to a smooth and well-drained one, requiring but a small sum now each year for its repair. When once the roads are made in proper shape, money is saved in the repair account forever afterward. Each reservation must have its own system of management, necessarily its own system of roads and trails.

The value of good roads for transportation and for making a forest accessible is obvious. However, they serve other purposes as well. It is necessary in all forests to have fire-lanes. Some authorities advocate the policy of cutting broad strips at certain distances through the forest, and of keeping these strips clear of debris of all kinds. Such policy is not a good one from our standpoint. The land so used is kept unproductive and is an expense each year. There are two ways in which a fire-lane is of use—a line from which to start a back-fire and a line at which a side-fire will stop for lack of fuel. A 2-foot trail will answer the same purpose and is much less expense; consequently, a system of roads and trails not only allows one to quickly reach the location of the fire, but serves to keep a fire from spreading, and is as cheap a protection against loss from fires as can be had. It also makes possible at once the utilization of wood and timber which otherwise would be useless, because of the expense necessary to bring it to market.

Systems of improvement cuttings ought to begin as soon as surveys can be made. The dead and dying trees and undesirable species should be removed and desirable species favored. Where young growth is too dense, thinnings should be made. Pruning may be resorted to, and when mature or hypermature trees are still standing, unless needed as

mother trees, they should be removed and marketed. Some of this work may be an expense, but this expense may justly be considered capital invested, for the result is an increased value of the forest. Nothing is lost and much is gained. Should a profit be made, it means an increase in the rate of interest.

On most of the reserves, if not on all, some planting will have to be done. The extent of this work can only be determined after topographical maps have been made. It will be necessary to determine what trees can yield the most valuable wood, in the least time, on a given area, and whether these trees are to be raised on the spot from seeds, seedlings or cuttings. When seedlings are to be used, it is cheaper to establish permanent nurseries than to purchase the stock from nurserymen.

On the Mont Alto Reservation a forest nursery has already been established, and this spring five acres will be devoted to nursery work. It is the intention of the Department of Forestry to plant up the numerous cleared places on the reservation with valuable species. In many cases burned areas and blanks in the forest will be planted up.

To do all this work it is necessary to have trained men. The management of the forest takes into consideration not only the present condition of affairs, but also those of the future that are likely to result from the trend of present conditions. Causes and effects must be known and the methods of producing beneficial results must be practised. Mistakes which cannot be changed for many years can easily be made through ignorance, consequently we need men on each reservation who haye a good general education and a special training for their work. On every 5,000 acres there should be a ranger or warden. Such a man ought to be sober, fearless and of considerable intelligence. He may have a nursery to care for; he must study his district and know it thoroughly and everything that goes on in it; at times he will be obliged to superintend the various operations that go on within his range.

The forester who has an efficient corps of rangers has half his work done when once it is planned. A forest of

20,000 to 50,000 acres cannot be comprehended in a year, nor even the local conditions surrounding and influencing the forest. An important step in the management of such a forest, then, is the employment of a trustworthy man of the neighborhood who is acquainted with the people, the land and conditions, to act as superintendent. He can have in charge the protection of the forest against fire and theft, the employment of laborers, when necessary, and can in many ways assist the forester in his duties. All of these reservation officials should be made peace officers, which, under existing laws, would make them both game and forest wardens with power to arrest without first serving a warrant. This may not seem necessary to one unacquainted with the forests and their inhabitants, but by one who has patrolled a forest it can be heartily appreciated. Above all, they should be appointed because of efficiency and not for political reasons.

Experiments to determine what species of trees are adapted to each State, and under what conditions such species are most quickly grown with best results can be made only by each State for itself. Pennsylvania has a splendid opportunity to begin these experiments at once, and already owns an ideal location where such experiments can be carried out. It is on the Mont Alto Reservation. Nursery work has already begun, and there are numerous old fields scattered over the estate which can be used to no better advantage than for demonstration purposes. We are in need of trained men. We have an ideal reserve on which to train men. Then why not take advantage of the opportunity and work out our salvation by establishing upon that reserve a school of practical forestry where young men of the State can learn the art at first hand and under the conditions which they will have to meet within the State?

We have seen the reasons why the State must both encourage private forestry and practise forestry on its own land, what has been accomplished in the past and the necessary steps to take in the immediate future. It remains now for those who know how, to use their influence to carry forward the work.

NEW METHOD FOR THE DETERMINATION OF THE VELOCITY OF LIGHT.

In the decennial publication of the University of Chicago may be found a suggestion by Professor Michelson of a new method of determining the velocity of light. The Professor reviews previous results, contrasts astronomical, electrical and optical methods and processes. Instead of the revolving toothed wheel of Fizeau, he suggests the use of a stationary grating, and by a double reflection of light from stationary and revolving mirrors, proposes to measure the eclipses the light suffers from the gratings. Figures accompany the original article, which make the author's plan clear. He estimates that the velocity of light can be measured to a probable error of only 5 kilometers.—*Scientific American.*

ACTION OF GELATINE UPON GLASS.

"In a paper read before the Académie des Sciences M. Cailletet describes the action of gelatine upon glass and other surfaces. When a glass object is covered with a thick layer of strong glue, the latter adheres strongly when wet, but upon drying it may be detached and carries with it glass scales of different thicknesses which have been lifted from the surface. The glass which is thus treated presents a surface whose designs resemble those of frost on a window-pane, and have a decorative effect.

"M. Cailletet made experiments with gelatine upon different substances, and found that tempered glass was easily attacked, as well as iceland spar, polished marble, fluorspar and other bodies. A sample of quartz cut parallel to the axis of the crystal was covered with two layers of fish-glue; after drying it was found that the surface was attacked and showed a series of striæ which were parallel, rectilinear and ran close together, while in the case of glass the striæ were curved. When certain salts were dissolved in the gelatine, namely, those which were easily crystallized and had no action, there was produced on the glass a series of engraved designs which had a crystalline appearance. Thus a solution of strong glue containing 6 per cent. of alum gave very fine designs somewhat resembling moss in appearance; other salts, such as hyposulphite of soda, nitrate and chlorate of potash, will produce analogous forms.

"M. Cailletet told of the strong mechanical action exerted by a layer of gelatine when drying. If a sheet of cardboard, lead or even wire-gauze is covered with a gelatine solution, the surfaces are seen to curve into the form of a cylinder as the gelatine contracts. Upon thin glass the effect is striking: when a layer of strong glue is spread upon a cylindrical vessel of thin glass the effort which it exerts when drying is sufficient to break the vessel with explosion. When a plate of thick glass covered with gelatine is examined by polarized light a powerful mechanical strain is observed in the glass, and the value of this effect could no doubt be measured."

The foregoing item is from the *Scientific American.* It may be of interest to note in connection with Cailletet's observations on the action of gelatine on glass, that the same has long been known, in this country at least, and has been applied commercially in the production of decorative glass.

W.

THE FRANKLIN INSTITUTE.

Stated Meeting, held December 17, 1902.

Commercial Production of Oxygen from Liquid Air.

By Eugene C. Foster, M.S.

It is my object in this brief communication to outline some work that has been done quite recently in this country looking toward the commercial utilization of liquid air. I shall not attempt to enter into a theoretical discussion nor to exploit the possibilities in liquid air along many lines; but shall confine myself to that which has actually been accomplished or is really in sight.

Some two years ago the eminent scientist, Raoul Pictet, in collaboration with Moriz Burger, read a paper before this Institute, in which he called attention to the feasibility of separating the constituent gases of the atmosphere after having first reduced them to the liquid state. The liquid-air plant in which Pictet made his experiments was then in New York City; with the substitution of a new liquefier, this plant is now in Washington, D. C., and is under my supervision. The paper referred to put into concrete form the suggestions that had been freely discussed among liquid-air men for some time previous, and constituted one of the few scientific presentations of that period concerning liquid air. To Pictet, probably more than to any one else, is due the credit for crystallizing the thought along this line; but within a few months the apparatus constructed under his supervision for the fractional distillation of liquid air has been dissembled at our plant on account of the mechanical difficulties its operation presented.

The problem of getting cheap oxygen from liquid air, therefore, remained unsolved, so far as this country was concerned. I am aware that considerable work has been done abroad in this line, and some of the published reports of what is estimated as being possible in this direction may seem more glowing than our report of what has been done;

but it is worth noting in this connection that even before publishing results or prospects the Columbia Liquid Air Company, owning the Washington plant referred to, has actually entered the market with oxygen from liquid air, and it is now on sale in many cities.

The liquid-air plant consists of suitable compressors, a pre-cooling device such as an ammonia machine, and a liquefier. The latter comprises coils of pipe so arranged that air at high pressure may be released and expanded, such expansion taking place about the coils which carry the inflowing stream of compressed air. This involves the principle of self-intensification; the absorption of heat by the gases in their change from the compressed to the more rarified state causes a certain percentage of the air to be so reduced in temperature as to condense and collect as a liquid.

We have examined a great many specimens of liquid air freshly made, and find that the percentage of constituent gases is not constant; nor does the liquid air made at the beginning of the run always correspond in constituent proportions with that made several hours after the plant has started. We may, for instance, find the oxygen content varying from 20 to 40 per cent., or even beyond these limits.

It has been demonstrated repeatedly that liquid air on standing for some time becomes rapidly richer in oxygen, and it is this fact that first brought forth the suggestion that oxygen might be accumulated in this manner from the atmosphere, the specially attractive thought being that the raw material is quite inexpensive. The question then arose as to how best to throw out the nitrogen, which is not wanted, and retain the oxygen, which is wanted. The difference in their boiling points, scarcely 12° C., is not so great as to make the problem an easy one; and it is with the question of how best to secure this desired end that we have been working. We cannot here give in detail the method used in thus fractioning the sample; but a clear apprehension of the results achieved may be imparted. More exactly, we have a two-fold problem: (1) how to secure liquid air which is initially rich in oxygen; (2) the choice of

a method of evaporation which will yield a rich product with the least possible loss of weight. Given liquid air with a 30 per cent. content of oxygen, if we could confine the loss by evaporation entirely to nitrogen we should have, with a reduction to one-half bulk, a material holding 60 per cent. oxygen; under like conditions, evaporation to two-fifths bulk would yield 75 per cent. oxygen. In one series of experiments recently we started with 31 per cent. oxygen, and after a loss of 61 per cent. of material (about three-fifths), we had secured 65 per cent. oxygen; this indicated a loss of 6 parts of oxygen coincident with a loss of 55 parts of nitrogen. We have since improved on the method used in that case, with much better results; but if we take our results as given—a 65 per cent. product after evaporating 61 per cent. of the liquid air—we find that they are better than results very recently reported by Linde, who secured only a 50 per cent. product under the same conditions; this is assuming that Linde has been correctly quoted by some very careful journals.

The first suggestion made above, that a part of the problem consists in producing liquid air that is initially rich in oxygen, is full of possibilities. With the completion of a series of determinations we are about to inaugurate, we hope to secure more light upon the causes of the variations in the liquefier; our plans include investigations not reported heretofore either in this country or abroad. A successful outcome of these experiments would enable us to run the liquefier with great uniformity for such a percentage of oxygen as we might wish to turn out, thus requiring no further evaporation.

The question of cost is a pertinent one. It must be remembered that the liquid-air plants constructed in this country have from the first been built with a view to turning out comparatively large quantities of liquid air. Certain departures have been made, therefore, from the beaten paths of European construction; the new liquefier to which I referred is no exception to the general rule which has prevailed, and the present plant, in several important details, is costly in comparison with one which we shall later

construct in the light of experience gained. Yet I propose to show you a remarkable cheapening in cost of oxygen over the chemical method of production, even with the present plant.

The new liquefier of the Columbia Liquid Air Company yields from 12 to 18 gallons of liquid air per hour, with an expenditure of 150 horse-power. For purposes of computation we shall take 12½ gallons, which is close to our minimum and not our average. In a run of ten hours this would therefore yield us 125 gallons of liquid air. If we place the cost of power at 1 cent per horse-power hour, we should have a cost of power of $15. Estimating, with a very large margin of safety, that this will yield us liquid air containing initially 35 per cent. oxygen, we should secure at least a 70 per cent. product by evaporating to two-fifths bulk, or 50 gallons. This should yield us 5,000 cubic feet of gas, at a cost of three-tenths cent per foot for power and raw material.

In answer to those who will say that this does not compare favorably with other estimates made on this subject, both here and abroad, I beg to say that this is not a theoretical estimate, but the conclusion reached in practical experience when based upon the cost of power suggested. Six months from now we expect to be able to make these figures look very large.

We produce a 70 per cent. material for sale as medicinal oxygen unless a different percentage is specified. It is conceded by many leading physicians that an oxygen approximating 100 per cent. purity would be unsafe for direct administration; and the effort to secure an admixture of air would only result in administering a product of unknown composition. On the other hand, a number of leading makes of medicinal oxygen have been examined, and only two specimens of those tested have gone over 50 per cent. oxygen. The 70 per cent. grade is deemed the best in cases of pneumonia and like conditions, and gives all the stimulation required, and is safe where resuscitation is aimed at. The advantage of definitely knowing what percentage is available is one not to be lightly considered.

The medicinal use of oxygen is one that has grown with remarkable strides within the last few years. The increase in this business alone in the next decade gives promise of being beyond present means of computation. Where a few years ago scarcely a hospital found it necessary to keep a stock of oxygen on hand, now not a modern institution is without it, and hundreds of physicians keep it in their private offices. The advantage of producing an oxygen which cannot by any means become contaminated with chemicals, such as the chlorine of the chemical process, is so apparent as to need no comment.

Large quantities of oxygen are used for the oxy-hydrogen light and in the industries. To what extent its use will be augmented along commercial lines no one can estimate, as the question is simply one of cheapness of production. It will readily be seen that the lower limit of cost is not in sight when made by the liquid-air process, for this process is but in its infancy and is bearing all the burdens of preliminary experimentation.

AMERICAN NITER INDUSTRY.

The recent discovery, in California, of extensive deposits of nitrate of soda of good quality, and the occurrence of that mineral in Nevada and some States on the Pacific Coast, is attracting capital from professional and business men, principally in the East. Much land is being taken up in California, and at least one large company with influential backing intends to undertake systematic development.

The California nitrate deposits are located in the Mohave Desert, extending from the northern portion of San Bernardino County to the southern section of Inyo County, and are 80 or 100 miles from Manvel, on the Santa Fé Railway. Some very high analyses of the mineral are reported, and it is estimated that there are about 22,000,000 tons in sight, though these figures are likely to be revised when active mining is in progress. It is believed, however, that the deposits are richer than the Chilean. At present the American Niter Company, whose president and promoter is W. W. Treat, of Boston, is planning large development. The company was formed in 1901 and controls about 35,000 acres, which have been located by the Baileys, of San Francisco, and others. Dr. Gilbert E. Bailey is the consulting engineer of the company. It will probably take two or three years before the property is in condition to ship to market, and by that time we may expect to hear something of interest concerning the Chilean combination, whose agreement expires in April, 1905. —*Charles C. Schnatterbeck, in Engineering and Mining Journal.*

THE CARNEGIE RESEARCH SCHOLARSHIP.

The Iron and Steel Institute calls attention to the scholarship to be awarded under the gift made to the Institute by Mr. Andrew Carnegie. The object of this scheme of scholarships is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry. There is no restriction as to the place of research which may be selected, whether university, technical school or works, provided it be properly equipped for the prosecution of metallurgical investigations. The appointment to a scholarship shall be for one year, but the Council may at their discretion renew the scholarship for a further period instead of proceeding to a new election. The results of the research shall be communicated to the Iron and Steel Institute in the form of a paper to be submitted to the annual general meeting of members, and if the Council consider the paper to be of sufficient merit, the Andrew Carnegie gold medal shall be awarded to its author. Should the paper in any year not be of sufficient merit, the medal will not be awarded in that year. Candidates, who must be under 35 years of age, must apply, on a special form, before the end of February, to the secretary of the Institute, at 28 Victoria Street, London. Candidates may be of any nationality.

HISTORY OF MECHANICAL STOKERS.

From an interesting paper on "Mechanical Stokers" lately presented before the Engineers' Society of Western Pennsylvania, by Mr. Edwin Fitts, of Pittsburg, we glean the following:

"As to the history of mechanical stoking, the first to use the idea of progressive burning of coal was James Watt. He distilled the coal on a dead plate at the mouth of the furnace and then pushed the coke back over the grate-area by hand. In this way a fairly good combustion can be obtained, but the labor is very excessive. Many variations of this plan were brought out from time to time, but the first mechanical stoker was patented in 1841 by John Juckes, an English inventor. This was of the tread-mill type and is in extensive use to-day, having been changed in detail of construction, and is now known as the chain-grate stoker."

DURABILITY OF THE PRESSED-STEEL CAR.

Almost every day brings forth some evidence of the extreme durability of the pressed-steel car. A few days ago in Pittsburg, one of these cars while being shifted was sent down a track which ran close to a stone wall of very substantial construction in the Panhandle freight yards. The brakes failed to work at the proper time and the car crashed into the bumper with terrible force. The upper part of the car was forced over the bumper against the stone wall, which was cracked in four places and which had every appearance of being ready to fall when it was taken down. The car was not seriously damaged, and on being placed on the tracks again was able to resume its trip without any attention whatever.—*Scientific American.*

PHYSICAL SECTION.

Stated Meeting, held April 24, 1901.

The Contributions of H. F. E. Lenz to the Science of Electromagnetism.

By W. M. Stine, Ph.D.

(*Concluded from p. 3 4.*)

PART II.

Heinrich Friedrich Emil Lenz was a voluminous writer as well as an indefatigable investigator, most of his experimental work having been done while he was a professor of physics at the University of St. Petersburg. The catalogue of the Royal Society contains a list of some fifty of his contributions. But little biographical information concerning him is available, probably owing to his residence having been so remote from the intellectual centers of Europe, and for the further reason that scientists, like other skilful artisans, scarcely leave any record but that of their experiments and papers; and probably there is an additional reason to be found from the fact that society at large, out of a requital for the scientist often having eschewed and neglected the humanities, forbears to consider his own life as a human document worthy of preservation. The author of the most insignificant literary work usually leaves enough of his life on record to show what the manner of the man was; but from the silence of social records, one must usually take for granted that the scientist was a man fulfilling at least the ordinary round of human life.

From brief encyclopædic notices in the French and German it is learned that Lenz was born February 12, 1804, at Dorpat, or the Russian Yurief. He seems to have studied theology in the earlier portion of his professional preparation; but, abandoning this subject, he devoted his attention to the natural sciences, and especially physics. What an

interesting chapter this portion of his life would furnish! In 1823–26 he accompanied O. von Kotzebue, the son of the celebrated poet, on the second of his voyages around the world. He traveled on this journey in the capacity of a naturalist, and upon his return made a valuable report of his observations to the Imperial Academy of Sciences at St. Petersburg. In 1828 he was elected an adjunct of the Academy, and in 1834 was made a fellow (Akademiker). About this time he became Professor of Physics at the University of St. Petersburg, and also taught the subject of physics at the Pedagogical Seminary. In 1864 he published a "Handbook of Physics," in two volumes. He at one time was the rector of the University and also served as its counsellor. His health failing, he made a journey to Italy, where, on February 10, 1865, he died at Rome.

Among the brief notices of the life of Lenz, there is one which for singularity deserves to be quoted at some length.* It proceeds with "Lenz was a German physician, and was afterward Professor of Medicine at the University, and numbered among his pupils the imperial princes (sons of Nicholas I)." That the subservience of Lenz to a few royal children should be his leading claim to public notice, while not a word is awarded to his scientific achievements, is a suggestive reflection on the material which passes for learning in our country. But even this brief notice is seen to be ludicrous when it is observed that the German "Physik" and "Physiker" have been translated "medicine" and "physician."

In order to acquire some familiarity with the intellectual complexion of Lenz, the few contributions which he made prior to his classical papers may be examined with interest. His mind was evidently of an eager, inquiring character, and apt to be absorbed by the dominant ideas of his time. The first paper has to do with "Considerations on the Temperature and Salt Content of the Water of the Ocean at Different Depths."† His second was a "Report of a Journey to

* "Lippincott's Biographical Dictionary," 1895.

† Pogg. Ann., XX, 1830, pages 73–130.

Bakou," and its contents were of a geological character. The third carries the pretentious title, "Physical Observations Made during a Voyage around the World in the Years 1823–26." These were followed by a second paper on the "Comparative Quantity of Salt Contained in the Waters of the Ocean,"* and in a fourth by some observations on the influence of temperature of the objects weighed on the movements of the beam of a balance. Finally, a sixth paper was devoted to "Variations that the Height of the Surface of the Caspian Sea Has Suffered to April (*sic*) of the Year 1830."

His first contribution of general scientific interest was the seventh in the list of his papers and was entitled, "On the Laws According to Which the Magnet Acts upon a Spiral When it is Suddenly Approached to, or Withdrawn from it; and on the Most Advantageous Method of Constructing Spirals for Magneto-electrical Purposes,"† which was read before the Scientific Academy at St. Petersburg, on November 7, 1832. It is significant to note the date of this paper in comparison with similar communications by Henry‡ and Faraday.§

In this paper Lenz frankly makes mention of Faraday's published experiments and states that he promptly repeated the principal ones. It will be seen from his own statements to what extent he verified the work of another, and how far he is entitled to be considered an original discoverer of the various phenomena of electricity induced from magnetism. In his own words from the English translation of his paper: "From the great interest which the late discoveries of Faraday in the field of electromagnetism must awaken in all the natural philosophers of Europe, it is to be expected that we shall soon receive many and various explanations. Up to the present moment we, here in the North, are only acquainted with the papers of Becquerel, Ampere, Nobili and

* Trans. in the *Edin. Jour. of Sci.*, VI, 1832, page 341.

† Eng. trans. by W. Francis, in Taylor's Sci. Memoirs, I, 1837, page 608; from Mem. Imp. Acad. des Sci., St. Petersburg, 1833, Vol. II, page 427.

‡ Published in October, 1832.

§ Read February 17, 1832.

Antinori, and Pohl; and as none of these authors has occupied himself with that branch of the subject to which I have directed my particular attention, I hasten to make known, as quickly as possible, the following contributions to the science of electromagnetism."

After successfully repeating the experiments of Faraday, Lenz applied himself as an investigator to find out how the phenomena of the magnetic action on a spiral, suddenly approached or removed from the magnet, might be produced in the easiest and most powerful manner. For this purpose he foresaw he must determine in what respect the characteristics of the "electromotive" spiral, as he called it, influenced the phenomena. The characteristics which he studied were:

I. The number of convolutions in the spiral.
II. The breadth.
III. The thickness.
IV. The substance of the convolutions.

The galvanometer which he employed was constructed with Nobili's double, or astatic needle; and was wound with seventy-four turns of 25-mil wire. "I wound," Lenz states, "the electromotive wire about a soft iron cylinder, which served as an armature, and was filed smooth and flat at those places where it was laid on the poles of the magnet. As the removal of the armature can be performed in a more certain, prompt and uniform manner than the placing of it on the poles, I have, in all my following experiments, given the results which were obtained by pulling away the armature, or by the sudden removal of the magnetism of the iron." With these elaborate preparations, Lenz proposed to investigate the various factors in the induction of electrical currents by the magnet. In passing, it is noteworthy that Lenz in this paper refers to the laws which Ohm had established for the electrical circuit, and he intimates that he had discovered these laws and relations for himself.*

He expresses the results of his experiments in a number of generalizations. In the first of these he states: "The

*Reference cited, page 613.

electromotive power which the magnet produces in a spiral with convolutions of equal magnitude, and with a wire of equal thickness and like substance, is directly proportional to the number of its convolutions." In modern phraseology, if a coil of n turns is moved in a magnetic field of strength N, the electromotive force in volts is defined by

$$e = -\frac{dN}{dt} \times \frac{n}{10^8}$$

In this generalization, then, Lenz has established a principle which is of fundamental importance, though from lack of all knowledge of the magnitude of the magnetic field which he employed, the effect of the time-rate-of-change of the magnetic field escaped him.

With respect to his second series of experiments, he states: "I wound the copper wire in six convolutions around a wooden wheel 28 inches in diameter, and placed the wheel on the iron cylinder. After having completed the experiment, I wound six convolutions of the same wire about the same iron cylinder." The electromotive power in each case was nearly identical; hence he concluded that "The electromotive power which the magnetism produces in the surrounding spiral is the same for every magnitude of the convolutions."

In his third investigation he employed coils of ten convolutions or turns, in which the wires were of different diameters, while he made for his tests three separate coils. The length of the wire in each case was 33 feet, and as the copper wires were short and relatively of large section, their resistance seems to have been negligible. The coils were tested successively on the same iron cylinder with the result that the electromotive force induced was practically constant for the three coils. His conclusion was, "The electromotive power produced in the spirals by the magnet remains the same for every thickness of the wires, or is independent of it."

The final conclusion is perhaps the most interesting of the series and the most important in its consequences. He proved very rigidly that "The electromotive power which

the magnet produces in spirals of wire of different substances, under like conditions, is the same for all substances." From one point of view this conclusion is correct and rigid, but for ferro-magnetic substances, while it still holds true, the permeability of such conductors being greater than unity, the element dN is affected and masks the results, though this refinement he was seemingly unable to detect. To show how thoroughly Lenz had grasped the principles of the electrical resistance of conducting substances and circuits, his own remarks will be placed in evidence. In discussing the experiments leading to the fourth conclusion, he says: "Nobili and Antinori, in their first paper on the electrical phenomena produced by the magnet,* have already determined the order in which four different metals are adapted to produce the electric current from magnetism. They arrange these in the following order: copper, iron, antimony and bismuth." He then observes: "It is particularly striking that the order is the same as that which these metals occupy also in reference to their capacity of conducting electricity; and the idea suddenly occurred to me, whether the electromotive power of the spirals did not remain the same in all metals, and whether the stronger current in the one metal did not arise from its being a better conductor of electricity than the others. With this in view, I examined four metals: copper, iron, platinum and brass." His method of experiment was simple and conclusive; spirals identical in form were made of the several metals and these were tested, pairing two of them at a time by connecting them by series into a single circuit whose free ends were connected by copper lead wires to a galvanometer. He placed now one spiral and then the other on the soft iron armature of the magnet. There was thus no change of resistance in the experiment if the electromagnetic conditions for induction were constant; and he should thus have obtained an equality of inductive effect. Between the circuits containing the pairs of coils he made full allowance for the elements of their resistance,

* Pogg. Ann., No. 3, 1832.

and upon calculating the electromotive power in unit terms for each coil, he found the values agreed remarkably well for the entire series of tests. To show the care with which he proceeded, he took pains to avoid any thermo-electric action at the joints. Thereupon he derived a law which he thus phrases: "The electromotive power which the magnet produces in spirals of wires of different substances, but in every other respect placed in exactly the same conditions, is completely identical for all these substances."

From the present time, though deservedly we look back upon the work of the noted classical investigators and call it great, yet from our prevalent ignorance of the mental attitude of these men toward their work, it acquires in our eyes almost a reverent aspect, and we imagine these men to have been gigantic in their intellectual grasp, when often they were most puerile. To show how these investigators often worked in the dark, and how, as a result, they made great ado over nothing, Lenz may again be quoted in illustration. Still speaking of his experiments with his electromotive spirals, he adds: "The conducting wires were connected with the ends of this spiral only by a single twist of the wires; the result of four readings with the connection in circuit amounted to 36·8°; upon this the same connection was made by twisting the ends of the wires ten times around one another as tightly as possible; the deviation again amounted to 36·8°. I finally pressed the last connections as tightly as possible with a pair of pincers, so that they were very much flattened; the deviation was 36·75°. We may therefore consider the connections made by tightly twisting the wires ten times around one another as quite sufficient."

In connection with the description of his experiments he, from his conception of the sine galvanometer, analytically investigated the magnitude of the currents produced. This work was done with some show of skill; but from a lack of full discrimination between ballistic and static deflections, the results obtained have considerable error, though this did not affect them since they were usually of similar magnitudes. It is indicative of the methods of Lenz that all his

results are corrected by least squares, a refinement far in excess of his possible instrumental accuracy.

In the final conclusion to his paper he proceeds to investigate the conditions for maximum electromotive power by deriving algebraical relations from his data. These interpretations of his experiments are rather formal and academical, and perhaps would be called crude in comparison with prevalent standards, and they would have been much more elegantly expressed by differential methods with which he shows himself to have been familiar by their introduction in later papers. Some of the quantities which he employs are based on bald assumptions; though by these means he arrives at some conclusions which appear to have been satisfactory to himself, they are devoid of interest to the present-day reader.

There have now been placed here, in their due order, the practically identical results of the leading scientists who laid the experimental foundations for the science of electromagnetism. Faraday and Henry are entitled to equal honors for the initiative work of discovery. The work of Lenz in comparison was to assign magnitudes and verify the phenomena, and later on to formulate a most important generalization. Of the three investigators, Faraday showed genius pre-eminently, for he sought after the causes of the phenomena, and developed the useful working hypothesis of tubes of force. Both Faraday and Henry neglected to attempt any mathematical statements and deductions from their experiments—Faraday from a lack of working knowledge of mathematics, and Henry because he evidently was not fully accustomed to the attitude of mathematical natural philosophy.

Again, of the three, the work of Lenz best stands comparison with modern methods, and he is pre-eminently the precise and analytical scientist seeking for relations and magnitudes. However, Lenz impresses one upon studying his work, as being singularly devoid of originality, and as being more nearly empirical, for he sets about his experiments largely in the spirit of the skilled workman who carefully examines every possible phase so that nothing may

escape him. Though this may be commendable, Lenz was seemingly not inspired by a high degree of the philosophical spirit and insight. One is impressed, however, upon reading the writings of Lenz, with the clear conception he displays of the momentary character of the induced currents. He undoubtedly realized that their action on the galvanometer-needle was ballistic, though he was in error in the estimation of the magnitudes of the current.

Following the first of what may be called the exact investigations of Lenz, in which he is undoubtedly entitled to precedence for determining the conditions upon which the magnitude of the electromotive force depended, he seems to have devoted himself to questions of electrical resistance. At first giving attention to the laws of divided circuits, he solved a number of intricate problems for the resistance of compound circuits.* However, it was in a paper read before the Academy at St. Petersburg, June 7, 1833, that he most clearly revealed his powers as an investigator. This paper was entitled, "On the Conductivity of Metals for Electricity under Varied Temperatures."† In it he states: "I had anticipated that there would be found a relation between the expansion of the metal under the action of heat and its lowered conductivity for electricity." He had examined copper, brass, iron and platinum, but by no means could he find any such temperature change of resistance as he anticipated, through the formulas which he employed for calculating the results of his experiments. But when he had developed his experiments on induced currents, he found through them a new means for further investigations of the supposed change of resistance; for he was thus enabled to put upon the circuit tested an electromotive force free from the uncertain element of the internal resistance of a battery which he had hitherto employed. Being able now to ascertain the resistance of all the elements of the circuit, he at once found and measured the temperature effect on the resistance of metals. To Lenz may be attrib-

* Dove's Reportorium, Bd. VIII.

† Pogg. Ann., Bd. XXXIV, page 418.

uted the priority in investigations of these phenomena and also their formulation; for he derived from his experimental data the expression

$$Yn = X + Yn + Zn^2$$

which may be recognized as the original for the now prevalent formula,

$$R_t = R_0 (1 + at + \beta t^2)$$

Usually only Matthiessen is mentioned as the authority for temperature changes of resistance, but the historical succession of authorities is Lenz,* Becquerel,† Arndsten‡ and Matthiessen§.

As a second result of the possession of the new and powerful means of investigation which the electromotive spirals had placed in the hands of Lenz, he promptly developed the necessity for some unit of resistance, and indeed employed this in terms of a unit length of copper wire of a definite section. The paper describing these experiments was read before the Academy, November 28, 1834, and was entitled, "On the Laws of the Conducting Powers of Wires of Different Lengths and Diameters for Electricity."‖ In this paper Lenz discusses Ritchie's observations on "conductibility"¶ and shows him to have been in error. He thereupon undertakes a lengthy discussion of the similar work of Ohm and Fechner, and in the course of his remarks he employs simple algebraic methods to phrase Ohm's law for simple and compound circuits, expressing his meaning through forms of analysis which are still accepted. Lenz, in his experiments, determined the resistance by the method of substitution, the current being obtained through electromotive spirals. His analysis begins with an expression of the familiar form,

$$J = \frac{E}{W} \qquad (1)$$

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* Pogg. Ann., Bd. XXXIV and XLV.
† Pogg. Ann., Bd. LXX.
‡ Pogg. Ann., Bd. CIV.
§ Pogg. Ann., Bd. CXV and CXXII.
‖ Taylor's Scientific Memoirs, Vol. I, page 311.
¶ *Phil. Trans.*, 1833, page 313.

J being his symbol for current strength, and W the resistance of a simple circuit including the spiral, lead wires and the galvanometer. A standard resistance of copper wire was then inserted, whose length was l, and whose resistance in terms of his unit copper wire was $\frac{l}{c}$. Then it followed that

$$J' = \frac{E}{W\frac{l}{c}} \tag{2}$$

and by combination,

$$W = \frac{l}{c}\frac{J'}{J - J'} \tag{3}$$

from which W was determined in terms of $\frac{l}{c}$.

Then substituting for the standard resistance the wire whose resistance R he wished to ascertain, he found, by solution of an expression, its resistance. J'' being the current in this case,

$$R = W\frac{J - J''}{J''} = \frac{l}{c}\frac{J'}{J''}\frac{J - J''}{J - J'}. \tag{4}$$

In this manner he obtained values for the conductivity of silver, copper, gold, iron, tin, lead, mercury, platinum, and many other conductors. Despite his crude standards for current and resistance, his methods are remarkably successful and the results are very close to the data which Matthiessen subsequently determined.

Throughout the discussion in this paper Lenz reveals a clear and concise grasp on his subject-matter, and exhibits a characteristically fine and well-trained mentality. He refers to Ohm's law as an axiom; and summing up his results, he states:

"The conductibility of wires of the same substance is inversely as their lengths and directly as their sections." Regarding this law as sufficiently proven, he continues, in explanation: "Still the method for determining the conductibility by the induced electrodynamic current offers so much facility and accuracy in observation that it appears to me worth while to apply this method." He had con-

ceived that some variations in the resistance of the battery employed as a source of electromotive force had been responsible for discrepancies in the results obtained by other investigators; and in contrast he considered his own source of electromotive force was, however, free from changes in internal resistance. At this time he had not yet grasped the conception which we now phrase under the term "impedance," though later on he developed this with much clearness. However, his circuits were low in reactance, and no doubt the small discrepancies, which at first he could not explain, were due to this effect; otherwise these methods were remarkably simple and effective. Probably nothing could more clearly illustrate that the first approximation of a scientific principle is often very simply obtained, and usually carries with it a degree of fame that is denied its elaborate and subsequent verification.

Though Lenz was not to receive wide recognition as one of the original discoverers of the phenomena of electricity induced from magnetism, yet his chief fame was to rest upon one terse and valuable generalization, which was to be known as Lenz's Law, and which was to serve for placing these phenomena under the broad generalization of the conservation of energy, soon to be developed and generally received, and which law should further prove one of the most practical for the application of the principles of electro-magnetic induction to electrical machinery. The enunciation of this law was first given in a paper read on November 29, 1833, before the Academy at St. Petersburg: it bore the caption, "Concerning the Direction of Galvanic Currents Excited by Electrodynamic Distribution." *

In its introduction Lenz takes exception to Faraday's rules,† and considers them insufficient, if not in error. He briefly summed up Faraday's statements to read: "(1) Be-

* Pogg. Ann., 1834, Bd. XXXI, page 483. The exact title of the paper is of interest; as it was first given scientific publication in the German, it reads, "Ueber die Bestimmung der Richtung der durch elektrodynamische Vertheilung erregten galvanischen Ströme."

† He had read these statements from Pogg. Ann., No. 5, 1832. Compare "Experimental Researches," Vol. I, pages 32–3.

tween parallel conductors, one of which carries a current, an opposing current is induced upon approach, and a current similarly directed upon withdrawal from the first conductor. (2) When a conductor is moved near a magnet the direction of the induced current depends upon the manner of cutting the 'magnetic curves.'" Lenz objected to this, and insisted that Faraday had here stated two wholly different laws for one and the same phenomenon. He based this singular objection upon what he calls "Ampere's beautiful theory," which regarded the magnet as a system of circularly directed galvanic currents. The objection, it must be confessed, appears trivial, and leaves Lenz open to the implication that he wholly failed to grasp the important significance of the magnetic curves or lines of force which Faraday had supposed constituted the magnetic field; and it further lays Lenz open to a suspicion that he was zealous for some opportunity to criticise the magnificent discoveries and work of Faraday.

This attitude of Lenz is all the more singular, since his first investigations proved conclusively that the cause of induction lay wholly apart from and without the circuit in which it took place; or, more briefly, in a medium surrounding it. Faraday clearly considered a magnet and a wire carrying a current as identical so far as they were both accompanied by magnetic curves; so his statements referring to two sets of conditions were very properly phrased into one general law. Again Lenz was correct in assuming that both the relations which he noted were aspects of one and the same phenomenon; his mistake originated wholly from adherence to Ampere's theory, and the failure to appreciate Faraday's conception of a magnetic field; though nearly all scientists and mathematicians at first were equally averse toward accepting this assumption of lines of force.

Since the processes by which Lenz finally arrived at his classical law are largely dominated by the criticism of Faraday's work, his objections will be given in some detail. In placing a stricture on the generality of Faraday's rules he instances the case of a conductor placed perpendicularly

to a second one in which a current is established. According to the interpretation which he placed on Faraday's rules, no current would be induced in this conductor when moved parallel with itself and with the inducing conductor. But this stricture is an obvious one since Lenz was inclined to be empirical rather than philosophical; and what should have led his thoughts to a conception of a field of force only in the end suggested to him an empirical generalization.

Faraday, in order to illustrate the sense of direction of the induced current relative to the polarity of the magnetic field inducing it, had resorted to the suggestion of a silver knife-blade, whose notched side was considered to be placed upward as it was moved along a bar, or cylindrical magnet, its edge cutting the lines of force. Lenz did not spare something of a sneer at the homely illustration, and considered it but an instance of the stricture he had placed on the supposed general law, since the knife-blade in fact was perpendicular to the axis of the inducing magnet, and should accordingly have had no current induced in it; a supposition which would have been true only for the position near the center of a very long straight magnet. The illustration, however, was a very apt one, and had in it something of the inspiration of genius on the part of Faraday, and its criticism showed the lack of this on the part of Lenz.

Upon the further study of Faraday's papers, and Nobili's comments upon them and his own experiments, the impression grew upon Lenz that all related electrodynamic distribution of currents might be simplified and brought together under the statement of a single, terse and comprehensive law; and guided by this idea, he entered upon a repetition, verification and extension of Faraday's experiments immediately following those by which he had established his discovery of the induced current. Lenz, through these experiments which he now instituted, was finally led to the elegant, though for him empirical, generalization which alone has made his name familiar to every student of electricity, and which serves more than any other detail to

make his investigations and papers classical. Stated in the language of its author, Lenz's law reads: *

"Wenn sich ein metallischer Leiter in der Nähe eines galvanischen Stromes oder eines Magneten bewegt, so wird in ihm ein galvanischer Strom erregt, der eine solche Richtung hat, dass er in dem ruhenden Drahte eine Bewegung hervorgebracht hätte, die der hier dem Drahte gegebenen gerade entgegengesetzt wäre; vorausgesetzt, dass der ruhende Draht beweglich nur in Richtung der Bewegung und entgegengesetzt wäre."

In a well-known and widely used text† the law is phrased in a form perhaps more familiar to the general reader, and is stated thus: "If the relative position of two conductors *A* and *B* be changed, of which *A* is traversed by a current, a current is induced in *B* in such a direction that by its electrodynamic action on the current in A, it would have imparted to the conductors a motion of the contrary kind to that by which the inducing action was produced."

The law expressed more tersely is: *The electrodynamic action of an induced current opposes equally the mechanical action inducing it.* When expressed in this form it is seen at once to be a corollary of the general law of the conservation of energy. Had Lenz expressly anticipated some such significance in it, his title to fame as a natural philosopher would have been established. However, the equivalence of the energy relations between the inducing and the induced currents did not seem to have occurred to him, his attention having been entirely absorbed by the mechanical relation detected in his experiments. It was not until some fourteen years later, when the principles of the conservation of energy were beginning to be grasped, that Helmholtz showed this law was a necessary corollary of the more general principle.

In order to obtain an idea of the working conceptions of induced currents which obtained among certain scientists in the early stages of the development of the science of

* Pogg. Ann., Bd. XXXI, page 483.
† Atkinson's Ganot's Physics.

electromagnetic induction, I translate a passage from the introductory discussion of Lenz's law, which Neumann gave in 1845.* It is to be recalled that Neumann gave mathematical expression and formulation to much of Lenz's work, as Maxwell did for that of Faraday. Neumann says:

"From the law of Lenz: the action which the inducing current or magnet exercises upon the induced conductor, if the induction results from the movement of the latter, is always in the nature of a check on its motion. And, further, the strength of the momentary induction is proportional to the velocity of the movement. From these considerations the general law of linear induction may be derived; and

$$E.\,Ds = -\varepsilon\,\nu\,C.\,Ds$$

In this formula, Ds is an element of the induced circuit, and $E.\,Ds$ is the electromotive force induced in the element Ds; ν is the velocity with which Ds is moved, while, according to the direction in which Ds is moved, C denotes the magnitude of the resolved action of the induction upon Ds when unit current is considered to be flowing in this element. The magnitude of ε is independent of the activity of the induced conductor, and in the case of linear induction may be regarded as a constant; but it is a function of the time, which decreases rapidly if its argument attains a finite value."

These views of Neumann are those of the pure analytical mathematician, and make no effort after a physical explanation of the phenomena or of their causation. They are based wholly on experimental results and are devoted to the establishment of relations between the various data. What is lacking in them is that physical aspect so finely expressed by Faraday in his conception of magnetic curves or lines of force. The pre-eminence of Faraday in this respect not only over Neumann, but Lenz more especially, is emphasized when it is considered that Lenz was so occupied with Ampere's theory of the magnet, that he did not

* Die math. Gesetzen der inducirten elektrischen Ströme; 1845, Engelmann, page 4.

go beyond it; while Faraday, as fully conversant with "M. Ampere's beautiful theory," * as he calls it, found this inadequate and established the conception of the magnetic field.

Lenz, in order to make his law clearer, proceeded to phrase it somewhat differently, though again missing the perception of its greater significance: "To each phenomenon of movement by electromagnetism there must correspond an electrodynamic distribution. Consequently, it is only necessary to produce motion through other means in order to induce a current in the movable conductor which shall be opposed in direction to that so produced in the electromagnetic experiments."

His attack on the proof of his law is logically arranged and carried out experimentally where data were not otherwise at hand. As stated, the items were, the dynamic fact being stated first, and the reversed inductive action second:

A. By Ampere's rule for parallel currents, two similarly directed currents mutually attract; while if oppositely directed they repel each other.

a. From Faraday's experiment, if a current is flowing in one of two parallel conductors, when the other conductor is caused to approach, a current of opposite direction is induced in it; and conversely.

B. By what became in subsequent years the principle of the electrodynamometer, if two circular currents are vertically placed with their planes at right-angles, having a common diametral axis of rotation, be the one fixed and the other free to move, the movable circuit will rotate until the two planes coincide and the currents have a common direction.

b. If two circuits are arranged as above, when the movable coil is quickly brought from a position of quadrature of its plane to one of coincidence with the fixed coil, a current is induced in the movable coil opposed in its direction to that in the inductor. This supposition was experimentally established by Lenz himself; and in it is recognized the principle of the earth inductor. In the apparatus used by

* "Experimental Researches," page 10, art. 38.

Lenz the circular frames were each wound with twenty turns of copper wire.

C. From an experiment of Nobili,* if from a fixed conductor, so long as to be considered as infinitely rectilinear, a short conductor be arranged at right-angles, and being free to move, be connected as a shunt from the fixed conductor, the direction of its current flow being from the fixed conductor, the shunt will move in the direction of the flow of the first current; and conversely.

c. If a shunt conductor, as above, be moved in the direction of the flow of current in the inductor, an induced current will be established, whose direction of flow is toward the inductor, or opposed to the direction in *C;* and conversely.

These, Lenz states, he considered the principal cases in which a galvanic current exercises an electrodynamic and an electro-inductive action upon an appropriate conductor. He then proceeded to examine the cases of mutual reaction between currents and magnets. These he prefaced with a discussion of Ampere's rule for finding the direction of an induced current by the friction of a man swimming in the circuit; and with something like perversity, proposed a modification derived from his own law. He gave as a rule, "If a conducting circuit is moved before the north pole of a magnet, an induced current results from the electrodynamic distribution, which streams through from the head to the feet, if one should be imagined to be in the circuit turned so as to view the north pole, and the motion of the conductor be toward the right hand." Just what conception Lenz himself had of this electrodynamic distribution (elektrodynamische Vertheilung) can not be obtained from his writings, if indeed he went so far as to establish a working conception for it. In his experiments he seems to have dealt with this electrodynamic distribution in the same sense that Faraday did with magnetic curves.

Proceeding to discuss the reactions between magnets and currents, Lenz resumes:

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* Pogg. Ann., No. 3, 1833, page 407.

D. From Oersted's experiments, a galvanic current brought over a magnetic needle, the direction of the current being from the south toward the north pole, will deflect the north end of the needle to the right.

d. If a linear conductor is placed over a magnetic needle at rest, and the needle is suddenly deflected by some force, a current is induced whose relation of direction is opposed to that in *D*; or, if the north pole of the needle is deflected toward the right, the flow of current will be from the north pole toward the south; and conversely. To prove this experimentally, Lenz employed a frame 1 foot square, wound with many turns of fine silk-covered copper wire.

E. From De la Rive's experiment, if a circular current, free to move, surround a long, cylindrical magnet, and the direction of its current coincides with the resultant direction of the Amperean magnetic currents, the conductor will move toward the center of the magnet; while if the direction of the two currents be opposed the conductor will tend to push out over the nearer pole.

e. If a circular conductor be thrust over an end or pole of a bar magnet, a current will be induced whose direction will be opposed to that of the Amperean currents of the magnetic pole. Should the circular conductor be removed quickly from the magnet, the induced current will have the direction of the Amperean currents. This result Lenz takes from Faraday's experiments.

F. By the experiment of Barlow with a rotating wheel, if a bar magnet is placed diametrically over the wheel with the north pole toward the left, and a current flows from this point on the periphery toward the center, the wheel will rotate in a clockwise direction; and conversely by changing the relative direction between current and pole.

f. Faraday, varying the experiment, still keeping the axis of the wheel vertical, placed the north pole of a curved magnet over a point on the periphery of the wheel, and the south pole beneath. Upon turning the wheel in a clockwise sense, a current was induced from the center toward the periphery; and conversely.

G. By Ampere's experiment a cylindrical magnet, rota-

table about its axis, will rotate in a clockwise sense regarding its north pole, when a current passes from the north pole to the center.

g. Faraday showed when such a magnet is rotated in a clockwise sense, and a galvanometer is connected to its center and the upward-pointing north pole, a current is induced whose direction is from the center toward the north pole; and conversely.

The contributions which Lenz has made toward the establishment of the science governing the phenomena of magnetically induced electrical currents have here been presented, and the relation which his work bears to that of others, perhaps more widely known, has in a manner been pointed out. As an investigator, Lenz is no doubt entitled to the honor of being one of the foremost scientists who established the principles of electromagnetism. The sensationalism of discovery seems not to have been reserved for him; and there is much evidence that he lacked originality and that his work was largely shaped by the hints he obtained from other investigators, rather than that it sprang from his own initiative. Neither in his writings nor experiments can he be called brilliant; he perhaps did little that would not subsequently have been done; yet all his work was of that solid, enduring character which forms the foundation of all science. His work was painstaking and exhaustive; he verified, extended and formulated. His papers exercised a wide influence on the development of electromagnetics, especially in Germany and France, and in one respect at least they were the most noteworthy of the period; and this respect is most essential, for in all his work he seems to have been guided by the quantitative aspect of science. In this sense the writings of Lenz seem modern, especially when compared with those of Faraday and Henry, or of Ampere and such contemporaries.

The present intention has been to bring the work of Lenz into prominent notice only so far as it was contributory to the discovery and development of magnetically induced electricity. But this represents but a portion of

the scientific labors and contributions of Lenz. Much of his subsequent work was important, and all of it more or less influential, but it has less general interest than that here given in detail. A mere outline of his subsequent work, however, will be given.

Lenz investigated Grove's battery quantitatively,* and certain aspects of electrolytic polarization, and the internal resistance of batteries.† He made a notable contribution on the cooling effect of a current passed through the junction of a thermo-electric couple.‡ Soon after Joule published his law for the heating effect of the electrical current, Lenz proceeded to investigate the entire subject with characteristic thoroughness, and gave Joule's law perhaps its most rigid verification, conspicuous also for its completeness.§

Lenz seems to have been especially keen to have recognized in the electromotive spirals an instrument for investigation capable of wide and exact application. By use of these spirals, he conducted numerous tests and measurements, which in method and apparatus very closely resemble modern permeametry in its simpler forms. With the aid of Jacobi he found a parabolic relation between the strength of the magnetization of an iron rod and the magnetizing current employed; and they also measured the magnetic moment for various types of magnets.‖

There was an additional line of investigation to which Lenz applied himself with the greatest enthusiasm and certainly with signal success; and this was a study of the properties and characteristics of the magneto-electric generators. He was led to establish experimentally that the plane of commutation does not coincide with the geometrical north-south plane; and in searching for the cause he found that the degree of shifting was in a sense a function

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* Pogg. Ann., Bd. LXVII.
† Pogg. Ann., Bd. XC.
‡ Pogg. Ann., Bd. XLIV.
§ Pogg. Ann., Bd. LXI.
‖ Pogg. Ann., Bd. XLVII and LXI.

of the current intensity; thus he recognized the existence of armature reaction.

Following the lead of Weber, he worked out with much thoroughness the relations for maximum current output for such machines; but perhaps the most important of all these later investigations was that series in which he studied the characteristics of the armature of the magneto-electric generator. As a result he was enabled to chart the sinusoidal electromotive wave form, the position and magnitude of a wave form due to counter-electromotive force, and the curve of magnetization as impressed and also as shifted by armature reaction.* In thus charting his data, he was one of the very earliest of the scientists who employed those graphical methods which are now so valuable and universally employed.

SWARTHMORE, PA., August 15, 1902.

THE BRUSH STORAGE-BATTERY PATENT EXPIRES.

The last barrier in the way of the general manufacture of electric-storage batteries was removed on March 3d by the expiration of the Brush patent on storage-battery electrodes. The *Electrical Review*, commenting on the fact, says that there may not be a great increase in the number of factories, but the magazine looks for improvement and extension of the use of power-batteries.

The electric motor-car manufacturers, it says, will profit more than anybody else by the new order of things. Lighter and better batteries for motor cars will appear, and the highly developed products of the European makers can be imported. In this way the prices can be reasonable, and the performance of electric motors greatly improved, with a resulting increase in their popularity and an augmenting business for manufacturers, both of machines and of batteries. Slight change is expected to occur in the power-station batteries.

The Brush patent, says the *Review*, was one of the most remarkable patents in the history of the electrical art. It covered completely the art of making plates by mechanically applied material, as a paste, powder, or in any other form. There have been repeated assaults on it in the Federal Courts, and enormous sums of money were spent in litigation to have the patent declared invalid, but in every instance it came forth victorious.

"To sum up," concludes the *Review*, "the result of the expiration of the Brush patent will be to improve and extend the use of power-batteries, though not markedly, and to increase greatly the quantity and quality of the cells for motor-car work."

* Pogg. Ann., Bd. XLVII and LXI.

Annual Reports of the Schools of Drawing, Machine Design and Naval Architecture for the Sessions of 1902-1903.

THE DRAWING SCHOOL.—The season just closed has been the most successful one in the history of the drawing school, not only in the number of the students, but also in the regularity of their attendance and the earnestness of their purpose, and it is gratifying to realize the great benefit that they have received.

After this training in constructive drawing, they are able to perceive the relations between the lines and surfaces of solids, and this creates a desire to understand the mathematics of these relations and the scientific reasons why certain results follow certain combinations.

Hence the study of mechanical drawing stimulates an ambition for a scientific education, and paves the way for it in so far as it trains the mind to form tangible conceptions and to put these on paper in such manner as to be readily understood.

Another great good that the school is doing is in raising the standard of work. A good drawing can be made just as easily and as quickly as a poor one, if proper methods are used. The former is clear, quickly understood and read, and not apt to lead to errors. It is positive and absolute in all it says. The latter is just the reverse. Instead of being expensive, a good drawing is positively economical, because, if made by a properly trained man, its first cost need be no more than that of a bad one, and it saves in the time of those who have to work to it, and in the greater accuracy of the results attained.

The excellence of our course of instruction, and the good work done by the instructors, are best attested by the fact that the attendance at the spring term was only 6 per cent. less than at the winter term.

THE GERMANTOWN JUNCTION BRANCH SCHOOL.—Mr. H. G. Norbom, Director of the Branch School at Germantown Junction, transmits the following report of its operations:

The attendance at the Branch School in the past year has been better than ever before, and it is very gratifying to see that the leading manufacturers surrounding the school appreciate the advantages in sending their young men for instruction.

There has been a steady increase every year. The school started some years ago with about a dozen scholars, while during the past year there were ninety-five scholars on the roll.

The results that have been shown by the scholars in neatness, accuracy and knowledge has been very gratifying to the instructors connected with the school, and a number of the young men have been helped to secure good positions with engineering concerns.

We beg to extend thanks to all who in one way or another have helped to make the Branch School successful.

WM. H. THORNE,
Director.

THE FOLLOWING STUDENTS ARE ENTITLED TO HONORABLE MENTION:

In the Senior Mechanical Class.

Arthur C. Heintze,
Leonard Hoerle,
John McMonagle,
Joseph Schenkel,
Henry Stranahan, Jr.,
Harry W. Fox,
J. Warren Smith,
Howard W. Howitz,
John Heenan,
Henry S. Cowell,
Harry Hartranft,
George M. Norman,
J. Monroe Bowen,
James McGettigan,
Elmer B. Severs,
Frederick Thomas Uezzell,
Miles L. Tully,
Edmund H. Berry,
Clarence Helmbold Wilson.

In the Intermediate Mechanical Class.

Herman Fink,
Chester D. Thorpe,
Walter D. Williams,
William Wentzell,
George Moxley,
Henry G. Weaver,
Albert F. Heeley,
G. Hagstrom,
Emil H. Schulze,
Samuel H. Blittersdorf,
Albert Smith,
James W. Marriott,
George F. Kauffman,
Harry Stange,
Frank Roller,
Charles F. Pfeiffer.

In the Junior Mechanical Class.

Harry Wickland,
P. H. Erisman,
John Reilly,
C. W. Leeds, Jr.

In the Architectural Class.

Daniel Sharp,
James F. Bowen,
Harry Stull,
John T. Rowley.

In the Free Hand Class.

David Bowers,
William E. Talbot,
John Talbot,
Max J. Grocki.

THE FOLLOWING STUDENTS ARE AWARDED SCHOLARSHIPS FROM THE B. H. BARTOL FUND, ENTITLING THEM TO TICKETS FOR THE NEXT TERM:

Harry Wickland,
George L. Gillingham,
G. Hagstrom,
C. W. Leeds, Jr.,
Daniel Sharp,
David Bowers.

THE FOLLOWING STUDENTS HAVING ATTENDED A FULL COURSE OF FOUR TERMS, WITH SATISFACTORY RESULTS, ARE AWARDED CERTIFICATES:

Edmund S. Allen,
Edmund H. Berry,
James F. Bowen,
Harry Hartranft,
Leonard Hoerle,
John McMonagle,

George Blair,
Chris. Buckius,
Henry S. Cowell,
Jesse Croft,
Amos Fisler,
Harry W. Fox,
Frederick Froehlich,
Otto Guenther,
Louis T. Hall,
John Heenan,
Edward Hill,
Howard W. Howitz,
Walter Russell,
Henry Stranahan, Jr.,
J. Warren Smith,
William F. Spaeth,
Daniel Sharp,
Harry Stull,
Miles L. Tully,
Frederick Thomas Uezzell,
William Uhlhorn,
Clarence Helmbold Wilson,
Charles Wilson,
James J. Woods.

FROM THE BRANCH SCHOOL.

George Quinn,
J. Edward Lennon,
Herman Wilmunder,
Thomas Allison,
Harry M. Cox,
George Hutchby,
Edwin Wright,
Matthew S. Esch,
James Devlin, Jr.,
Harry Tennison,
Franklin S. Reinhold,
Richard Rigler,
Charles Reinhardt,
J. William Smith,
James P. Shaffer.

THE SCHOOL OF MACHINE DESIGN.—In point of numbers the condition of the school continues satisfactory, the registration this session being larger than ever before. The increase has been in the courses in mathematics, the technical courses, for which these are a preparation, showing a slight decrease.

Most of the students taking up the preparatory work are doing so with the object of qualifying for the more advanced courses; but it is our experience that many of these find the continued night work, after a day's labor, a too severe stress on their powers of endurance and are unable to continue. In consequence, the technical classes are largely made up of men who have obtained their mathematical training from outside sources, and this training frequently proves inadequate to properly carry on the work in hand. Our advanced classes have, therefore, always been small and are likely to continue so. Much diligence and great interest have been shown in all divisions of the course, and the students are to be congratulated on their persistent and painstaking efforts, which, judging from the progress made, cannot fail to be of lasting benefit to them and to reflect credit upon the school.

The class in algebra has been in charge of Mr. L. M. Arkley, and I am indebted to his care and skill for its prosperous condition.

LUCIEN E. PICOLET,
Director.

THE FOLLOWING HAVE COMPLETED THE FULL COURSE AND ARE AWARDED CERTIFICATES:

M. M. Borden,
W. J. Thompson,
J. C. Wobensmith.

THE FRANKLIN INSTITUTE SCHOOL OF NAVAL ARCHITECTURE.—I have the honor to report that the School of Naval Architecture has met with a substantial increase in its enrollment over last year, and that the average attendance of the senior division students during the winter term was 98 per cent., and for the spring term 98·6 per cent., the majority of this division making the full attendance; that of the junior division was 92·2 per cent. for the winter term and 91·6 per cent. for the spring term. Nine of the senior division have attended the full term of two years and, having passed the examinations, will be graduated.

The senior class in Practical Naval Architecture has studied the various details in construction of the different classes of vessels, making sketches and calculations for the same. In Theoretical Naval Architecture they have calculated weights of material, centers of gravity, strength of structure of the hull under varied conditions, trim, stability, etc. Their home work has shown wonderful energy, considering that the drawings, etc., are made without the usual adjuncts of a drawing office. In fact, this class has exhibited more than ordinary intelligence and its members are above the average, being neat and painstaking.

The junior students have progressed rapidly in both theoretical and practical naval architecture, and have also shown marked zeal in their work in class and at home. Numerous drawings beyond the average in neatness and accuracy have been made from blue-prints lent for that purpose.

The class is indebted to the following gentlemen for donating valuable prizes for attendance, home work and examinations: Mr. C. H. Cramp, President of the Wm. Cramp & Sons, shipbuilders and engineers, Philadelphia, Pa. Mr. Clement A. Griscom, President of the International Navigation Company, Philadelphia, Pa.; Mr. H. W. Morse, President of the New York Shipbuilding Company, Camden, N. J.; Mr. Lewis Nixon, President of the United States Shipbuilding Company, New York City.

Mr. C. H. Cramp has also offered a special prize to the apprentices employed by his firm who are students of this school and show marked efficiency in home work and examinations, as well as paying the fees of those who pass the examination at the end of each term.

ALEX. J. MACLEAN,
New York City, April 17, 1903. *Director.*

THE FOLLOWING STUDENTS ARE AWARDED CERTIFICATES:

John Sutton,
Augustus Walko,
C. Chesley,
Sam'l H. MacDowell,
J. Wilber Yeats,
C. D. Wallach,
Harold Elfreth,
Lionel Levy,
Wassilly Wassilief.

Notes and Comments.

MOVING SIDEWALK SCHEME FOR NEW YORK.

The proposal made by Mr. Max Schmidt, of the Multiple Speed and Traction Company, to Bridge Commissioner Lindenthal is that the city should build the subway under the city from Bowling Green to the new East River Bridge at an estimated cost of $3,200,000, and lease it to the Multiple Company at a nominal rent, the company agreeing to operate a moving-platform transit system on the basis of a 1-cent fare. This proposition is now under consideration by the Rapid Transit Commissioner and pending his report no other proposition will be made.

Since the above proposition was made, a law has been pointed out by the Rapid Transit Commissioner, prohibiting the city from making any investment that does not guarantee a return of at least 4 per cent. This will doubtless cause a modification of the company's proposal as to the terms of the lease, but not as to who shall build the subway.

The company has full confidence in the success of the moving-platform system of transit, pointing to its success in other cities, and says it is willing to guarantee the city a return of 4 per cent. on its investment, but that it cannot do so on a 1-cent fare basis.—*Electrical World.*

ALUMINUM.

Messrs. Burgess and Hambuechen show the great influence which the ever-present, thin, invisible film on an aluminum surface has upon the success of various operations. The film is supposed to have considerable strength and continuity, and if it is broken or removed by mechanical means the aluminum immediately forms a new one. In soldering aluminum the principal difficulty seems to be due to the failure of the alloy used as a solder to adhere to the aluminum, a condition attributable to the protective film, which must be eliminated before the metals can unite. A successful solder consists of about 21 per cent. of zinc, 76 per cent. of tin and 3 per cent. of aluminum; it may be applied directly to a cleaned aluminum surface without the use of a flux, and at a temperature but little above that which is necessary for soldering copper or iron. There are certain advantages in the apparent complication which the use of a flux involves; a suitable solvent for the oxide film increases the rapidity of the soldering process, increases the certainty of adhesion and enables cheaper soldering mixtures to be used. The requirement for such a flux is that it should dissolve the coating and leave a clean surface for the solder to unite with, upon application of heat; it seems that water cannot be a component of a suitable flux. A material which, for certain solders, forms an admirable flux, is stearic acid; by applying it to a freshly scraped aluminum surface and then applying a tin-lead-zinc alloy, the matter of soldering aluminum presents scarcely greater difficulties than does the soldering of other metals. This almost ever-present coating upon aluminum is also the source of difficulty in the deposition of a permanent coating of other metals

upon aluminum surfaces; while it is very easy to deposit a layer of metal upon aluminum from almost any plating solution, in the great majority of operations the resulting coating can readily be removed, sometimes in remarkably thin and continuous layers. The prime requisite in successful depositions on aluminum is the complete removal of the protection film, so that the electro-deposited metal may be applied over the complete surface of and in intimate contact with the aluminum; if this condition is fulfilled, and the coating is non-porous, it will be durable. The converse of this operation, *i. e.*, the electro-deposition of aluminum upon other metals, appears to be impossible from aqueous solution. From the fact that, for equal weights, aluminum possesses about four times the energy as does zinc, considerable attention has been given to the problem of substituting aluminum for zinc in primary cells; but as a matter of fact, aluminum does not behave well as the electro-positive metal of a battery and attempts to use it in practice have almost universally failed. The results of measurements made by Mott, of the potential of aluminum in various electrolytes (measured against a normal electrode) are given in diagrams and tables. It appears that, of the various materials tested, ammonium fluoride would be the best material to use in connection with aluminum for battery purposes.—*Electrochem. Ind.*

THE MOND NICKEL PROCESS.

The success of the Mond nickel process, as carried on in England, has been seriously hindered by the discovery that the process is dangerous to the health of the men employed. During the summer there were over twenty cases of slight poisoning after a breakdown in the plant, and during the past month there have been three deaths from the same cause. The works are now shut down and both Dr. Mond and the company are sparing no expense in investigating the cause of these mishaps. Inquiries in the same direction are also being conducted by the English Government experts. It is stated that the symptoms are different from anything previously known to the medical profession, so that they are not likely to have been caused by the carbonic oxide employed. The source of danger is probably the volatile compound of nickel and carbonic oxide which is formed. There have been many difficulties encountered in the working out of this process and it is over ten years since the first experimental plant was erected. Doubtless, however, experience will eventually point out a way of operating with safety. Many successful metallurgical and chemical processes in their beginning have suffered from drawbacks.—*English Mining Journal.*

ELECTROLYTIC REFINING OF GOLD.

Dr. D. K. Tuttle gives an illustrated description in the January impression of *Electrochem. Industry* of the Wohlwill process of gold refining used at the Philadelphia United States Mint. The feature of the process is the electrolyte, which is composed of a gold trichloride solution, rather strongly impregnated with free hydrochloric acid; the latter addition is necessary, because if a gold anode be placed in a neutral or only slightly acid solution of gold chloride, gold will be deposited on the cathode, but little or no gold will be

dissolved from the anode, free chlorine being given off instead. The temperature of operation is 50° to 55° C., this increased temperature serving to reduce the voltage required, and at the same time to diminish the amount of free acid necessary to suppress evolution of chlorine at the anodes. Circulation of the electrolyte is also necessary. The cost of the hydrochloric acid required in the bath is 20 cents per 1,000 ounces of deposited gold. Any platinum present in the bullion can be recovered; it dissolves, but is not deposited with the gold. When the electrolyte becomes sufficiently charged with platinum, the gold is first precipitated by sulphur dioxide and reserved; then the platinum remaining in solution is separated as ammonium-platinum chloride; lastly the copper is recovered by passing the wash waters over iron scrap. He does not treat by this process bullion having a fineness of less than 940 gold.

INK FOR RUBBER STAMPS.

The vehicle used in the preparation of inks for rubber stamps is glycerin, a non-drying substance; so that pads charged with the color may remain usable indefinitely. Such ink, of course, is not as desirable as one that would thoroughly dry on exposure, but the latter—regular printing ink—requires a kind of handling too troublesome for most users of stamps.

Anilin colors are usually employed as the tinting agents.

The following is a typical formula, the product being a black ink:

Nigrosin	3 parts.
Water	15 "
Alcohol	15 "
Glycerin	70 "

Dissolve the nigrosin in the alcohol, add the glycerin previously mixed with the water, and rub well together.

Nigrosin is a term applied to several compounds of the same series which differ in solubility. In the place of these compounds it is probable that a mixture would answer to produce black as suggested by Hans Wilder for making writing ink. His formula for the mixture is:

Methyl violet	3 parts.
Bengal green	5 "
Bismarck green	4 "

A quantity of this mixture should be taken equivalent to the amount of nigrosin directed.

These colors are freely soluble in water, and yield a deep greenish black solution.

We have found the anilin compound known as brilliant green to answer in place of Bengal green.

As to the permanency of color of this or any anilin ink, no guarantee is offered. There are comparatively few coloring substances that can be considered permanent even in a qualified sense. Among these, charcoal takes a foremost place. Lampblack remains indefinitely unaltered. This, ground very finely with glycerin, would yield an ink which would perhaps prove

serviceable in stamping; but it would be liable to rub off to a greater extent than soluble colors which penetrate the paper more or less. Perhaps castor oil would prove a better vehicle for insoluble coloring matters.

Almost any anilin color may be substituted for nigrosin in the foregoing formula, and blue, green, red, purple, and other inks obtained.

Insoluble pigments might also be made to answer as suggested for lamp-black.—*Drug. Circ. and Chem. Gaz.*

A UNIQUE PLANING MACHINE.

A unique planing machine has recently been installed in the Washington Navy Yard for the purpose of finishing the surfaces of the propellers used in the tank in which models of warships are tested. The ponderous machine weighs 10 tons, while some of the propellers on which it operates weigh only 2 pounds each, their diameters varying from 5 inches to 2 feet. Although designed especially for planing helicoidal surfaces, there is a provision for planing irregular surfaces by means of cam-wheel attachments. The propellers planed may have two, three or four blades, may be either right or left-handed, and the blades may be all in one plane, or they may be tilted either forward or backward, not to exceed 10 degrees. The bronze castings are bolted to a circular table, which is given oscillatory motion about a vertical axis. Above the table, the setting for the tool-heads has an up-and-down movement, governed by the position of the fulcrum on a walking-beam. The feeds are automatic, and when all are thrown in, the four tool-heads and two cam-rollers work in unison.—*Iron Age.*

Book Notices.

Penrose's Pictorial Annual for 1902-03. An illustrated review of the graphic arts. New York: Tennant & Ward. 8vo. (Price, $1.50.)

The eighth volume of this interesting annual has just been issued. Much space is devoted to the various color-processes, and a number of excellent specimens of three- and four-color prints are shown. Process work is treated from the commercial as well as the artistic side, and the book is full of good examples of half-tones. There are 100 pages of reading matter and over 200 illustrations, printed on good paper and attractively bound. A. R.

Letters and Lettering. A treatise with 200 examples, by Frank Chouteau Brown. Boston: Bates & Guild. 1902. 8vo. (Price, $2.00.)

While the literature on this subject is already quite extensive, the present work is a welcome addition. It deals especially with classic and mediæval letters and their application to modern book-making. The work is exhaustive and contains considerable historical information; the illustrations are appropriate and numerous, and include, in addition to the standard forms of letters, medals, medallions, book-covers, posters, title-pages and tablets. The book will be most useful to artists and master printers. A. R.

Experiments with Vacuum Tubes. By Sir David L. Salomons, Bart., M.A. (With 54 illustrations.) 12mo, pp. vii + 79. London and New York: Whittaker & Co. Price, 2 shillings.)

The author presents in this booklet some new methods which he has devised for the study of the phenomena caused by the electric discharge in so-called vacuum tubes. He has observed that many of these phenomena are obscured or confused, and their correct interpretation rendered difficult if not impossible by reason of the employment of currents of very high E.M.F. and large currents. He accordingly employed in his study of the phenomena very small E.M.F. and very small current. By this method, he claims, the difficulties which beset earlier investigators disappear and the phenomena are seen in their purity. Then on raising the E.M.F., successive superadded phenomena appear, which would be extremely puzzling had the start not been made in this manner. Then follows a detailed account of numerous experiments under varying conditions with a great variety of tubes.

A second part of the book describes the author's observations on the effects produced upon electric discharges in rarefied gases when placed in the magnetic field. W.

Telephone Lines and methods of constructing them. By Walter C. Owen, Consulting Telephone Engineer, etc. (With 265 illustrations.) 12mo, pp. viii + 389. London and New York: Whittaker & Co. 1903. (Price, 5 shillings.)

This work deals exhaustively with the details of telephone line construction—overhead and underground—and is intended to afford telephone employees and others interested in the subject a general knowledge of the methods employed in various countries. The book is profusely illustrated and should prove a useful addition to telephone literature. W.

Chemical Technology, or chemistry in its application to arts and manufactures; with which is incorporated Richardson & Watts' Chemical Technology. Volume IV. Edited by W. J. Dibdin, F.I.C., F.C.S., etc. Electric Lighting, by A. G. Cooke, A.M., A.M.I.E.E.; Photometry, by W. J. Dibdin, F.I.C., F.C.S., etc. 4to, pp. xiii + 378. Philadelphia: P. Blakiston's Son & Co. 1903. (Price, $3.50 net.)

The volume above named forms Part IV of the well-known Chemical Technology of Groves & Thorp.

The aim of the authors, in which they have succeeded very satisfactorily, has been to present, in concise, connected and scientific order, the principles and important facts bearing on their respective themes, and to present their data in such manner as to be serviceable to all those to whom a general knowledge of the subjects considered would be of value. W.

Traité de Chimie Physique. Les Principes. Par Jean Perrin, Chargé du Cours de chimie a la faculté de sciences de Paris. 8vo, pp. xxvi + 300, avec 38 figures. Paris: Librarie Gauthier-Villars. 1903. (10 fcs., relié 13 fcs.)

This work appears to be a thoroughly modernized version of the principles of physical chemistry, the evolution of which in recent years has so materially modified our notions of chemical action. W.

Franklin Institute.

[*Proceedings of the Stated Meeting held Wednesday, April 15, 1903.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, April 15, 1903.

President JOHN BIRKINBINE in the chair.

Present, 44 members and visitors.

Additions to membership since last report, 14.

Mr. L. E. Levy presented the report of Mr. Lewis S. Ware, delegate of the Institute to the meeting of the Association of Inventors and Industrial Artists, held in Paris, December 11, 1902, to present a testimonial to M. Millerand, ex-Minister of Commerce. [The report was accepted with the thanks of the Institute. It is printed as an appendix to these minutes.]

In the absence of Mr. Marshall G. Moore, Mining Engineer, Cambria Steel Company, Mr. Birkinbine presented his paper on "The Explosion in the Rolling Mill Mine of the Cambria Steel Company," at Johnstown, Pa. This disastrous accident happened on July 10, 1902, and involved the loss of 112 human lives. The subsequent investigation of the case demonstrated beyond doubt that the explosion was caused by carelessness on the part of some one of the miners in using a naked light, in direct violation of stringent regulations to the contrary. [Mr. Moore's paper is referred for publication.]

Mr. Rufus J. Foster, of Scranton, Pa., followed with a paper giving a historical sketch of the origin and development of the Miners' Safety Lamp, illustrating the subject by the exhibition and description of a large number of these devices. The thanks of the meeting were tendered to Mr. Foster for his interesting communication.

Mr. Wilson L. Gill, of New Paltz, New York, read a paper describing "The School City." This is a system which Mr. Gill has devised for the training of the children in the schools in the practice of popular government. The system is in successful operation in many schools throughout the United States and in Cuba. The intention of the speaker is, if possible, to have the plan adopted in the public schools of Philadelphia.

Mr. L. E. Levy spoke in highly commendatory terms of the value of the system, and offered the following resolution, which was adopted:

Resolved, That the Franklin Institute recommends the system of "The School City," proposed by Mr Gill, to the consideration of the Committee on Science and the Arts.

Adjourned.

WM. H. WAHL, *Secretary.*

REPORT

OF MR. LEWIS S. WARE, DELEGATE OF THE INSTITUTE TO THE MEETING OF THE ASSOCIATION OF INVENTORS IN PARIS, DECEMBER 11, 1902.

To the President and Members of the Franklin Institute.

GENTLEMEN:—In compliance with your wishes I acted as delegate of the Franklin Institute at a meeting held at the Arts et Métiers, Paris, on Decem-

ber 11, 1902, to present a memorial medal to M. Millerand, ex-Minister of Commerce, for services he had rendered to inventors of all countries who have occasion to examine French patents.

The question at issue was fully explained by Maitre Claude Couhin, the President of the Association of Inventors and Industrial Artists. Comparison was made between the exceptional facility offered in the United States, England and Germany for detailed examination of patents and all documents relating thereto. In France, on the other hand, there are numerous formalities to be contended with.

The expired patents were deposited in the Conservatoire des Arts et Métiers, while the others were in the building of the Ministry of Commerce. The demands for patents were made in another section of the city, and the money installments for patent applications was a formality that was carried out elsewhere. Through the exertions of M. Millerand the whole subject has been much simplified, and all patents, whether new or old, all demands, consultations, etc., may now be made at the Conservatoire des Arts et Métiers, Paris. The questions relating to the issuing of patents is at present entirely different from what it formerly was, for then several years would elapse before a new patent could be consulted in its printed and official form; only a certain number of these were ever issued *in extenso*. At present, all patents are to be published in full; their price is to be 1 franc, regardless of size. The Government appropriation for the printing was $60,000 per annum; but of the 13,000 patents granted only 6,500 were hitherto printed. At present the Imprimerie Nationale undertakes the printing of all the patents for the sum mentioned; this consequently means an annual saving to the French Government of $60,000. Another reform that has been instituted by the ex-Minister of Commerce is the question of annual dues on patents. Since 1844 it has been the custom to consider as canceled any patent upon which the inventor had not promptly paid a given sum at a specified date; but now a delay of three months is allowed and a nominal fine is demanded. There is yet another reform that was the outcome of M. Millerand's exceptional energy; this relates to the industrial artists. The hitherto existing laws were very contradictory; no one knew whether it was the rulings of 1793 or those of 1806 which were in vogue. The difficulty has been overcome through the law of 1902, by which creators of artistic models and design are protected under clauses readily understood.

Very truly,

LEWIS S. WARE.

Committee on Science and the Arts.

[*Abstract of proceedings of the stated meeting held Wednesday, April 1, 1903.*]

MR. CHAS. E. RONALDSON in the chair.

The following reports were adopted:

(No. 2219.) *Method and Apparatus for Storing Acetylene.*—Messrs. Claude, Hess and Fouché. (Applicant, Mr. John S. Seymour, New York.)

ABSTRACT.—The essential feature of this ingenious process and apparatus is the utilization of the great solubility of acetylene gas in acetone, for storing comparatively large quantities of the gas dissolved in acetone under pressure, the solvent being absorbed in a porous material such as asbestos or porous bricks, contained in a steel cylinder. A suitable reducing valve permits the gas to be drawn off and delivered to the burners at the proper pressure for giving the best illuminating effect. The report is reserved for publication in full.

For the novelty and utility of these inventions the John Scott Legacy Premium and Medal is recommended to the inventors. [*Sub-Committee.*—Dr. H. F. Keller, Chairman; Wm. McDevitt, Louis E. Levy, Dr. Wm. O. Griggs.]

(No. 2258.) *Multiple-Unit System of Electric Traction.*—Frank J. Sprague, New York.

ABSTRACT.—The system is covered by U. S. patents Nos. 660,065-6, October 16, 1900, and 696,880, April 1, 1902, granted to the applicant. The object is to permit the operation of electric railway trains made up of any number of units, and to enable the train to be rapidly accelerated and maintain the maximum tractive effort on the wheels. This is accomplished by making each unit a motor car and attaching a controlling cable to all controllers, so as to enable the various units to be combined in a train and operated by a single controller at each end of the train. (The technical details of the system will appear in the full publication of the report.)

In consideration of the important advance in the operation of electric roads which these inventions represent, the award of the Elliot Cresson Medal is made to the inventor. [*Sub-Committee.*—Wm. C. L. Eglin, Chairman; A. Falkenau, Clayton W. Pike.]

(No. 2260.) *"Hylo" Incandescent Electric Lamp.*—W. J. Phelps.

ABSTRACT.—As its name indicates, the lamp referred to is of the "turn-down" kind. The report refers to the various plans devised to accomplish this in practice, viz.: (1) The combination of a rheostat and switch by which the lamp may be given varying brightness. (Introduced by the T.-H. Company.)

(2) The placing of a choke coil in the socket of incandescent lamps to be used on A. C. circuits, and by the aid of variable resistance and inductance, as a switch is turned the lamp is dimmed. (The Reis regulating socket.)

(3) A lamp in which two filaments are placed in series, and at the turn of a milled head at the side of the lamp-base placing them in parallel. (The Edison night lamp.)

(4) A two-filament lamp so connected that when placed in a special socket several combinations may be effected: (*a*) at first stop they are in series; (*b*) at second, one is short-circuited; (*c*) at third, both are put in parallel; (*d*) at fourth, the circuit is opened. (The tri-light lamp.)

(5) A lamp of two filaments: one of the kind regularly in use, and the other a very fine filament of moderate length, which, by a switching device, can be put in series with the other. When so arranged, the combined resistance is such that only enough current gets through to bring the *small* filament to incandescence, while the other is not even heated to a dull red.

The invention here referred to is of this last-described type, and appears to be the first of the kind to have proved commercially successful. Of the various patents issued to applicant for this invention, U. S. patent No. 603,705 appears to be the most important.

The report alludes to the general demand for a practical "turn-down" lamp in hospital wards, hallways, bathrooms, bedrooms (especially in hotels) and similar places, and proceeds to give some comparisons of current consumption and candle-power between the normal filament and the fine one, and refers to the extremely long life of the latter (4,000 hours of continuous service).

The merits of this form of "turn-down" lamp are that it can be used with ordinary lamp sockets without special fixtures or wiring; that it shows very good economy; that in turning down, the circuit is not opened, nor any process gone through with that would involve the possibility of short-circuiting the series; and that the life of the small filament greatly exceeds that of the large one.

The award of the Certificate of Merit is made to the inventor. [*Sub-Committee.*—Arthur J. Rowland, Chairman; Thomas Spencer.]

(No. 2266) *The Kodak Developing Machine.*—Eastman Kodak Company, Rochester, N. Y.

ABSTRACT.—The apparatus is designed to enable the photographic operator to carry on the development of negatives without the aid of a dark-room and without any handling of the film whatever until it is developed and fixed. The report will be published in full.

The report concludes by recommending the award of the John Scott Legacy Premium and Medal to Arthur W. McCurdy, the inventor of the device, for the excellent performance and certainty of action of the apparatus and the ingenuity shown therein. [*Sub-Committee.*—Lucien B. Picolet, Chairman; Dr. Wm. O. Griggs, Urbana C. Wanner, Samuel Sartain.]

The following reports passed first reading:

(No. 2226.) *Label-Pasting Machine.*—Fred. W., Thomas V. and Walter Myers, New York and Philadelphia.

(An advisory report.)

(No. 2276.) *Process and Apparatus for Butter-Making.*—Chas. M. Taylor, Jr., Philadelphia.

W.

Sections.

(*Abstracts of Stated Meetings.*)

CHEMICAL SECTION.—Thursday, October 30, 1902. Dr. Henry Leffmann in the chair. Present, 38 members and visitors.

Prof. W. P. Mason, of Troy, N. Y., gave an informal address on "The Water Supply of Gibraltar," illustrated by a number of lantern photographs.

January 2, 1903. Mr. Lyman F. Kebler in the chair. Present, 32 members and visitors.

The paper of the evening was presented by Mr. Albert P. Sy, Frankford

Arsenal, Philadelphia. Subject: "The Stability of Nitrocellulose and Nitrocellulose Powders." Informal communications were presented by Drs. H. F. Keller and Henry Leffmann.

January 29th. Mr. Lyman F. Kebler in the chair. Present, 6 members.

Prof. Chas. E. Munroe, of Washington, D. C., read a paper on "The Methods of Making the Census of Manufactures in 1900."

The Executive Committee named Dr. Robt. H. Bradbury and Mr. W. E. Ridenour, to be president and secretary of the Section respectively, for the year 1903.

March 19th. Dr. Robert H. Bradbury in the chair. Present, 52 members and visitors.

Dr. Harry C. Jones, Johns Hopkins University, gave a lecture on the subject of "What Physical Chemistry has Done for Chemistry."

PHYSICAL SECTION.—November 6th. Prof. Geo. F. Stradling in the chair. Present, 18 members and visitors.

Dr. Louis A. Bauer, of Washington, D. C., read the paper of the evening on "Terrestrial Magnetism."

January 15, 1903. Dr. Henry Leffmann in the chair. Present, 26 members and visitors.

Dr. Leffmann presented an illustrated communication on "The Development of Modern Ideas as to the Form and Position of the Earth." Prof. Luigi d'Auria read a paper on "A Relation between the Mean Speed of Stellar Motion and the Velocity of Wave Propagation in a Universal Gaseous Medium, Bearing on the Nature of the Ether."

ELECTRICAL SECTION.—November 13th. President Thomas Spencer in the chair. Present, 32 members and visitors.

Mr. Leonard B. Marks, of New York, presented a paper "On the History of the Development of the Enclosed Arc Lamp." Mr. Rulon, of Philadelphia, described and exhibited an improved form of primary battery.

January 8, 1903. Mr. Thomas Spencer in the chair. Present, 46 members and visitors.

The paper of the evening was read by Messrs. C. C. Rosenberg and H. S. Balliet, of Bethlehem, Pa., on the subject of "Automatic Electric Railway Signaling," which was profusely illustrated with lantern photographs.

February 12th. President Thomas Spencer in the chair. Present, 69 members and visitors.

Mr. W. J. Hammer, of New York, read a communication entitled "Notes on Recent Electrical and Scientific Developments Abroad." The subject was fully illustrated.

The Executive Committee named the present officers to serve for the year 1903.

March 7th. President Thomas Spencer in the chair. Present, 32 members and visitors.

Mr. C. E. Farrington, of Boston, read a paper on "Defective Machine Insulation."

MINING AND METALLURGICAL SECTION.—November 20th. Mr. Alex. E. Outerbridge, Jr., in the chair. Present, 43 members and visitors.

The communication of the evening was presented by Mr. Albert Sauveur, of Boston, on "Metallography," which was fully illustrated with the aid of apparatus, experiments and diagrams. The subject was discussed by Messrs. Paul Kreuzpointner, Robt. Job, W. R. Webster, the chairman and the author.

December 18th. Mr. James Christie in the chair. Present, 64 members and visitors.

The papers of the evening were as follows: "Coal Handling," by Mr. F. V. Hetzel; and "Ore Handling," by Mr. A. C. Johnston, of Philadelphia. The speakers illustrated their remarks by the exhibition of numerous lantern views.

February 5, 1903. Dr. Wahl in the chair. Present, 13 members and visitors.

Mr. E. F. Morse, of Trumansburg, N. Y., exhibited and described his new electrical pyrometer, called a "Heat Gauge," for the accurate measurement of high temperatures.

March 5th. Dr. E. Goldschmidt in the chair. Present, 56 members and visitors.

Mr. Howard W. Dubois, of Philadelphia, gave an account of "Observations Made During a Recent Mining Reconnoissance in the Rockies of British Columbia." The speaker illustrated his remarks with the aid of a number of extremely fine lantern photographs.

Stated Meeting, April 2d. Dr. E. Goldschmidt in the chair. Present, 54 members and visitors.

The Executive Committee announced the appointment of the following to serve as officers of the Section for the current year, viz.: President, James Christie; Vice-Presidents, Prof. F. L. Garrison and Wm. R. Webster; Secretary, G. H. Clamer; Conservator, Dr. Wahl.

The paper of the evening was presented by Mr. Clamer. Subject: "The Study of Alloys Suitable for Bearing Purposes." The author illustrated his remarks with the aid of a large number of photomicrographs and tables. The discussion which followed was participated in by Messrs. Paul Kreuzpointner, A. E. Outerbridge, Jr., Robert Job and the author. (Paper and discussion will appear in the *Journal*.)

G. H. CLAMER,
Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—*Twenty-first Stated Meeting*, Dec. 11th. Dr. Leffmann in the chair. Present, 40 members and visitors.

Mr. Janson, representing the Eastman Kodak Company, gave a description and made a demonstration with a new developing machine, dispensing with the use of the dark-room.

Dr. Leffmann and Mr. U. C. Wanner gave some account of a number of new photographic chemicals sent for exhibition by the Farbenfabriken von Elberfeld Company. The subject was illustrated by the exhibition of specimens of the products, photographic prints, lantern pictures, etc.

February 14, 1903 Dr. Leffmann in the chair. Present, 15 members and visitors.

Mr. John Bartlett presented a communication (read by the Chairman) on "Under- and Over-exposures." The subject was freely discussed.

Mr. M. I. Wilbert made some remarks in connection with several lantern views representing an improved induction coil made by the Heinze Electrical Company, of Boston.

Dr. Leffmann exhibited several lantern photographs of ancient and recent maps, and commented upon the subject.

Twenty-second Stated Meeting, April 4th. Dr. Henry Leffmann in the chair. Present, 48 members and visitors.

Dr. Leffmann and Mr. F. A. Keely presented a joint contribution on Agar-agar. Dr. Leffmann gave an account of the origin and uses of the plant, and Mr. Keely described and exhibited under the microscope the characteristic forms of diatoms found therein by which it can be identified when used as a substitute for gelatin.

Mr. U. C. Wanner presented a communication on "Some Experiments in Stand or Tank Development," which was illustrated by the exhibition of a number of negatives and prints made from negatives developed in tanks with dilute developer.

Mr. Martin I. Wilbert addressed the meeting on "The Use of Lantern Slides as an Aid in Object Teaching." The speaker illustrated the subject by showing a number of slides (loaned by Prof. Jos. P. Remington) exhibiting botanic and pharmacologic objects colored by students of the St. Louis College of Pharmacy.

Mr. Howard W. DuBois exhibited a number of artistically colored slides and made some remarks on the method of coloring.

Dr. Leffmann exhibited a number of slides representing typical desert vegetation.

M. I. WILBERT,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—January 22, 1903. Mr. Jas. Christie in the chair. Present, 54 members and visitors.

Mr. Kern Dodge, of Philadelphia, read a communication entitled "Notes of Observations on Power-Cranes," with numerous lantern illustrations.

Mr. Ernest M. White, of Philadelphia, described an improved and much simplified "compound engine" of his design.

February 5th. Dr. E. Goldschmidt in the chair. Present, 23 members and visitors.

Mr. Carl Barth, of Swarthmore, Pa., addressed the meeting on "Slide-rules in the Machine Shop as Part of the Taylor System of Management."

Stated Meeting, April 16th. Mr. James Christie in the chair. Present, 34 members and visitors.

Mr. Hoadley, representing the Waterbury Tool Company, exhibited and described a new mechanical movement, consisting of a flexible joint for shafting, so designed as to transmit motion when the angle between the two sections of shafting is as much as 60°.

Mr. J. F. Rowland, Jr., then opened the discussion of the subject of Fuel Oil, which was participated in by Messrs. Lovekin, Parker, Wurtz, Eppelshimer and the chairman.

D. EPPELSHIMER, JR.,
Secretary.